# EAU Guidelines on Renal Transplantation

A. Breda (Chair), K. Budde, A. Figueiredo, E. Lledó García,
J. Olsburgh (Vice-chair), H. Regele
Guidelines Associates: R. Boissier, V. Hevia,
O. Rodríguez Faba, R.H. Zakri
Guidelines Office: C. Bezuidenhout

© European Association of Urology 2025

European Association of Urology

# TABLE OF CONTENTS PAGE


1. INTRODUCTION 4
   1.1 Aim and objectives 4
   1.2 Panel Composition 4
   1.3 Available publications 4
   1.4 Publication history 4

2. METHODS 4
   2.1 Introduction 4
   2.2 Review 5

3. THE GUIDELINE 5
   3.1 Organ retrieval and transplantation surgery 5
      3.1.1 Living-donor nephrectomy 5
      3.1.2 Organ preservation 6
         3.1.2.1 Kidney storage solutions and cold storage 6
         3.1.2.2 Duration of organ preservation 7
         3.1.2.3 Methods of kidney preservation: static and dynamic preservation 7
      3.1.3 Donor Kidney biopsies 9
         3.1.3.1 Procurement Biopsies 9
            3.1.3.1.1 Background and prognostic value 9
         3.1.3.2 Type and size of biopsy 10
         3.1.3.3 Summary of evidence and recommendations 10
         3.1.3.4 Implantation biopsies 10
      3.1.4 Living and deceased donor implantation surgery 10
         3.1.4.1 Anaesthetic and peri-operative aspects 10
         3.1.4.2 Immediate pre-op haemodialysis 11
         3.1.4.3 Operating on patients taking anti-platelet and anti-coagulation agents 11
         3.1.4.4 What measures should be taken to prevent venous thrombosis including deep vein thrombosis during and after renal transplant? 11
         3.1.4.5 Is there a role for peri-operative antibiotics in renal transplantation? 12
         3.1.4.6 Is there a role for specific fluid regimes during renal transplantation and central venous pressure measurement in kidney transplant recipients? 12
         3.1.4.7 Is there a role for dopaminergic drugs, furosemide or mannitol in renal transplantation? 13
      3.1.5 Surgical approaches for first, second, third and further transplants 13
         3.1.5.1 Single kidney transplant - living and deceased donors 14
         3.1.5.2 Robot-assisted kidney transplant surgery 16
         3.1.5.3 Dual kidney transplants 16
         3.1.5.4 Ureteric implantation in normal urinary tract 16
         3.1.5.5 Transplantation/ureteric implantation in abnormal urogenital tract 18
      3.1.6 Donor complications 18
         3.1.6.1 Long-term complications 18
      3.1.7 Recipient complications 19
         3.1.7.1 General complications 19
         3.1.7.2 Haemorrhage 19
         3.1.7.3 Arterial thrombosis 19
         3.1.7.4 Venous thrombosis 20
         3.1.7.5 Transplant renal artery stenosis. 20
         3.1.7.6 Arteriovenous fistulae and pseudo-aneurysms after renal biopsy 21
         3.1.7.7 Lymphocele 21
         3.1.7.8 Urinary leak 21
         3.1.7.9 Ureteral stenosis 22
         3.1.7.10 Haematuria 23
         3.1.7.11 Reflux and acute pyelonephritis 23
         3.1.7.12 Kidney stones 23

3.1.7.13 Wound infection 23
3.1.7.14 Incisional hernia 24
3.1.8 Urological malignancy and renal transplantation 24
3.1.8.1 Malignancy prior to renal transplantation 24
3.1.8.1.1 In the recipient 24
3.1.8.1.2 In the potential donor kidney 25
3.1.8.2 Malignancy after renal transplantation 25
3.1.9 Matching of donors and recipients 25
3.1.10 Immunosuppression after kidney transplantation 27
3.1.10.1 Calcineurin inhibitors 27
3.1.10.2 Mycophenolates 28
3.1.10.3 Azathioprine 29
3.1.10.4 Steroids 29
3.1.10.5 Inhibitors of the mammalian target of rapamycin 30
3.1.10.6 Induction with Interleukin-2 receptor antibodies 31
3.1.10.7 T-cell depleting induction therapy 31
3.1.10.8 Belatacept 32
3.1.11 Immunological complications 32
3.1.11.1 Hyper-acute rejection 33
3.1.11.2 Treatment of T-cell mediated acute rejection 33
3.1.11.3 Treatment of antibody mediated rejection (ABMR) 34
3.1.12 Follow-up after transplantation 34
3.1.12.1 Chronic allograft dysfunction/interstitial fibrosis and tubular atrophy 34

4. REFERENCES 36

5. CONFLICT OF INTEREST 56

6. CITATION INFORMATION 56

7. COPYRIGHT AND TERMS OF USE 57

# 1. INTRODUCTION

## 1.1 Aim and objectives

The European Association of Urology (EAU) Renal Transplantation Guidelines aim to provide a comprehensive overview of the medical and technical aspects relating to renal transplantation. It must be emphasised that clinical guidelines present the best evidence available to the experts but following guideline recommendations will not necessarily result in the best outcome. Guidelines can never replace clinical expertise when making treatment decisions for individual patients, but rather help to focus decisions - also taking personal values and preferences/individual circumstances of patients into account. Guidelines are not mandates and do not purport to be a legal standard of care.

## 1.2 Panel Composition

The EAU Renal Transplantation Guidelines panel consists of an international multidisciplinary group of urological surgeons, a nephrologist and a pathologist. All experts involved in the production of this document have submitted potential conflict of interest statements which can be viewed on the EAU website: http://www.uroweb.org/guideline/renal-transplantation/.

## 1.3 Available publications

A quick reference document, the Pocket Guidelines, is available in print. This is an abridged version which may require consultation together with the full text version. All documents are are accessible through the EAU website Uroweb: http://www.uroweb.org/guideline/renal-transplantation/. A EAU Guidelines App for iOS and Android devices is also available containing the Pocket Guidelines, interactive algorithms and calculators, clinical decision support tools, guidelines cheat sheets and links to the extended guidelines.

## 1.4 Publication history

The EAU published the first Renal Transplantation Guidelines in 2003 with updates in 2004 and 2009. A comprehensive update of the 2009 document was published in 2017. This 2024 document is an update of the 2017 Renal Transplantation Guidelines. The next update of the Renal Transplantation Guidelines will be published in 2027.

# 2. METHODS

## 2.1 Introduction

The 2025 edition of the Renal Transplantation Guidelines is a reprint of the 2024 version. For the 2024 Renal Transplantation Guidelines, new and relevant evidence was identified, collated and appraised through a structured assessment of the literature. Broad and comprehensive literature searches, covering the Renal Transplantation Guidelines were performed, covering a time frame between May 31st 2020 and 1st April 2023. Databases searched included Medline, EMBASE, and the Cochrane Libraries. Detailed search strategies are available online: http://www.uroweb.org/guideline/renal-transplantation/.

Recommendation within the Guidelines are developed by the panels to prioritise clinically important care decisions. The strength of each recommendation is determined by the balance between desirable and undesirable consequences of alternative management strategies, the quality of the evidence (including certainty of estimates), and the nature and variability of patient values and preferences. This decision process, which can be reviewed in the strength rating forms which accompany each guideline statement, addresses a number of key elements:

1. the overall quality of the evidence which exists for the recommendation [1];
2. the magnitude of the effect (individual or combined effects);
3. the certainty of the results (precision, consistency, heterogeneity and other statistical or study related factors);
4. the balance between desirable and undesirable outcomes;
5. the impact and certainty of patient values and preferences on the intervention

Strong recommendations typically indicate a high degree of evidence quality and/or a favourable balance of benefit to harm and patient preference. Weak recommendations typically indicate availability of lower quality evidence, and/or equivocal balance between benefit and harm, and uncertainty or variability of patient preference [2].

### 2.2 Review

This document was subject to independent peer review prior to publication in 2017. Publications ensuing from systematic reviews have all been peer reviewed.

# 3. THE GUIDELINE

## 3.1 Organ retrieval and transplantation surgery

### *3.1.1 Living-donor nephrectomy*

The endoscopic (laparoscopic) approach is the preferred technique for living-donor nephrectomy in established kidney transplant programmes [3]. Nevertheless, open surgery, preferably by a mini-incision approach, can still be considered a valid option, despite increased pain in the post-operative period [4].

Endoscopic living-donor nephrectomy (ELDN) includes:

- Pure or hand-assisted transperitoneal laparoscopy;
- Pure or hand-assisted retroperitoneal approach;
- Laparo-Endoscopic Single Site Surgery (LESS);
- Natural Orifice Transluminal Endoscopic Surgery-assisted (NOTES);
- Laparo-Endoscopic Single Site Surgery and robotic-assisted transperitoneal or retroperitoneal approach.

There is strong evidence in support of laparoscopic living-donor nephrectomy (LLDN), including several systematic reviews and meta-analysis, which have compared its safety and efficacy to open donor nephrectomy. Laparoscopic living-donor nephrectomy is associated with similar rates of graft function and rejection, urological complications and patient and graft survival. However, measures related to analgesic requirements, pain, hospital stay, and time to return to work are significantly better for laparoscopic procedures [5-8].

Standard LLDN is usually done through 5 and 12 mm ports, but has also been done with 3 or 3.5 mm ports [9]. According to a recent meta-analysis, hand-assisted LLDN is associated with shorter operative time and warm ischaemia, but equivalent safety and overall results [10]. Laparoscopic living-donor nephrectomy can also be performed with robotic assistance, with equivalent results according to a systematic review [11]. However, the numbers are still low and recent studies, including a meta-analysis, have reported higher complication rates for this approach [12, 13].

Laparo-endoscopic single site surgery nephrectomy allows the surgeon to work through a single incision (usually the umbilicus) with a multi-entry port. The same or a separate incision is then used for kidney withdrawal. Several retrospective and at least three prospective randomised trials demonstrated equivalent safety and results, with a trend towards less pain and better cosmetic results [14, 15]. However, LESS is considered a more technically demanding procedure when compared with classic LLDN and its role is yet to be defined.

Natural orifice transluminal endoscopic surgery-assisted transvaginal nephrectomy avoids the abdominal incision needed for kidney extraction, aimed at minimising scaring and pain. Initial reports suggest that this approach is safe, however experience with this technique is still highly limited [16].

Right LLDN has been considered more difficult, yielding inferior results. However, both left and right LLDN can be performed with equivalent safety and efficacy according to large retrospective studies, systematic reviews and meta-analysis [17, 18].

Laparoscopic living-donor nephrectomy has brought attention to potential failures of different devices such as, endoscopic staplers and locking and non-locking clips, used to secure the renal hilum [17]. There is no scientific evidence that one device is safer than another for securing the renal artery [19-21]. However, the U.S. Food and Drug Administration (FDA) and the manufacturers of locking clips have issued a contraindication against their use in securing the artery during LLDN.

| **Summary of evidence** | **LE** |
|---|---|
| Laparoscopic living-donor nephrectomy is associated with similar rates of graft function and rejection, urological complications and patient and graft survival to open nephrectomy. | 1a |
| Measures related to analgesic requirements, pain, hospital stay, and time to return to work are significantly better for laparoscopic procedures. | 1a |

| Recommendations | Strength rating |
|---|---|
| Offer pure or hand-assisted laparoscopic/retroperitoneoscopic surgery as the preferential technique for living-donor nephrectomy. | Strong |
| Perform open living-donor nephrectomy in centres where endoscopic techniques are not implemented. | Strong |
| Perform laparo-endoscopic single site surgery, robotic and natural orifice transluminal endoscopic surgery-assisted living-donor nephrectomy in highly-specialised centres only. | Strong |

### *3.1.2 Organ preservation*

In kidneys donated after cardiac death (DCD) evidence suggests that warm ischemia contributes to worse graft outcome. Donor hemodynamic parameters (systolic blood pressure, oxygen saturation and shock index: heart rate divided by systolic blood pressure) may be predictors of delayed graft function (DGF) and graft failure; however, further studies are required to validate this [22]. The duration of asystolic warm ischaemia during procurement in DCD donors is associated with increased risk of graft failure. Overall five year graft failure (including primary graft non-function) was associated with longer asystolic warm ischaemia times [23]. Extraction time (beginning with aortic cross-clamp and ending with placement of the kidneys on ice), is an important factor for DGF. Incidents of DGF were 27.8% and 60% at up to 60 minutes and 120 minutes extraction time, respectively [24].

A retrospective study of 64,024 living donor kidney transplants found that cold ischaemia time (CIT), human leukocyte antigen (HLA) mismatch, donor age, panel reactive antibody, recipient diabetes, donor and recipient body mass index (BMI), recipient race and gender, right nephrectomy, open nephrectomy, dialysis status, ABO incompatibility, and previous transplants were independent predictors of DGF in living donor kidney transplants [25]. Five-year graft survival among living donor kidney transplant recipients with DGF was significantly lower than in those without DGF. Delayed graft function increased the risk of graft failure by more than 2-fold [25].

#### *3.1.2.1 Kidney storage solutions and cold storage*

There are two main sources for kidney graft injury: ischaemia (warm and cold), and reperfusion injury. The aims of modern kidney storage solutions include: control of cell-swelling during hypothermic ischaemia; maintenance of intra- and extra-cellular electrolyte gradient during ischaemia; buffering of acidosis; provision of energy reserve; and minimisation of oxidative reperfusion injury. There is no agreement on which of the mechanisms is most important for post-ischaemic renal graft function [26]. No storage solution seems to combine all mechanisms. Previously, Euro-Collins was widely used, but is no longer recommended.

Presently, University of Wisconsin (UW), and histidine-tryptophan-ketoglutarate (HTK) solution are equally effective and are standard for multi-organ or single kidney harvesting procedures. The characteristics of HTK are its low viscosity, low potassium concentration and low cost. University of Wisconsin solution has been the standard static cold preservation solution for the procurement of liver, kidney, pancreas, and intestine [27]. University of Wisconsin, HTK, and Celsior solutions have provided similar allograft outcomes in most clinical trials, however, some differences have become apparent in studies and registry reports [28, 29]. Marshall's hypertonic citrate solution (MHCS) is also suitable for use in the preservation of human kidneys before transplantation [30]. In experimental studies of kidney preservation, HTK and UW retained a greater capacity to preserve endothelial structure and pH buffering function during warm ischaemia in comparison to MHCS and Celsior, especially in uncontrolled DCD donors [31]. In the absence of a cost-utility analysis, the results of the meta-analysis from the randomised controlled trials (RCTs) comparing UW with Celsior and MHSC in standard cadaver donors, indicate that these cold storage solutions are equivalent [32].

For living donors, in whom immediate kidney transplantation is planned, perfusion with crystalloid solution is sufficient. Kidneys coming from DCD donors, especially those uncontrolled are high-risk marginal organs due to prolonged warm ischaemia periods, and require specific measures in order to diminish the rate of non-function or DGF. More than 60% of kidney grafts currently come from Expanded Criteria Donors (ECD) (any donor aged > 65 years and/or donor aged > 55 years with any of the following: acute renal dysfunction, stroke or arterial hypertension) [33].

| Summary of evidence | LE |
|---|---|
| University of Wisconsin and histidine-tryptophan-ketoglutarate solution are equally effective and are standard for multi-organ or single kidney harvesting procedures. | 1b |
| A meta-analysis of randomised controlled trials indicated that University of Wisconsin and Celsior solution are equivalent in standard cadaver donors. | 1a |

| Recommendations | Strength rating |
|---|---|
| Use either University of Wisconsin or histidine-tryptophan-ketoglutarate preservation solutions for cold storage. | Strong |
| Use Celsior or Marshall's solution for cold storage if University of Wisconsin or histidine-tryptophan-ketoglutarate solutions are not available. | Strong |

*3.1.2.2 Duration of organ preservation*

Cold ischaemia time should be as short as possible. Kidneys from ECDs after brain death (DBD) and DCD donors are more sensitive to ischaemia than standard criteria donors. Kidneys from DBD donors should ideally be transplanted within a 18 to 21 hour time period; there is no significant influence on graft survival within a 18 hour CIT [32, 34, 35]. Kidneys from DCD donors should ideally be transplanted within 12 hours [36], whilst kidneys from expanded criteria donors should ideally be transplanted within 12 to 15 hours [37, 38].

*3.1.2.3 Methods of kidney preservation: static and dynamic preservation*

Whichever method is used, cold storage is critical. The use of cold preservation as a therapeutic window to deliver pharmacological or gene therapy treatments could, from an investigational point of view, improve both short- and long-term graft outcomes [39]. Cooling reduces the metabolic rate of biological tissue minimising continuous cellular processes that lead to depletion of ATP and accumulation of metabolic products. Reperfusion with oxygenated blood invokes ischaemia-reperfusion injury. Hypothermic perfusion does not enable normal cellular metabolic function or prevent depletion of energy stores [40]; however, it prevents the deleterious effects of simple cooling, especially in the setting of prolonged warm-ischaemic time in uncontrolled DCD donors. Two meta-analyses suggest that hypothermic machine perfusion reduces DGF compared with static cold storage [41, 42]. Outcomes for primary non-function (PNF) are less clear, but one meta-analysis limited to high quality studies suggests a reduction in PNF rates with hypothermic machine perfusion [42]. A Cochrane systematic review and meta-analysis showed that hypothermic machine perfusion (HMP) reduced the risk of DGF when compared to static cold storage (CS) for kidneys from both DCD and DBD donors [43].

The increased demand for organs has led to the increased use of "higher risk" kidney grafts. Kidneys from DCD donors or grafts coming from ECDs are more susceptible to preservation injury and have a higher risk of unfavourable outcomes [44, 45].

Dynamic, instead of static, preservation could allow for organ optimisation, offering a platform for viability assessment, active organ repair and resuscitation. *Ex situ* machine perfusion and *in situ* regional perfusion in the donor are emerging as potential tools to preserve vulnerable grafts. Preclinical findings have driven clinical organ preservation research that investigates dynamic preservation, in various modes (continuous, pre-implantation) and temperatures (hypo-, sub-, or normothermic) [40].

There are several methods of kidney preservation including:

- Initial flushing with cold preservation solution followed by ice storage. However, the limitations of static CS in preserving marginal organs such as ECD kidneys has led to the increased use of dynamic methods.
- Current dynamic preservation strategies entering clinical practice and the different modalities of their use are: hypothermic machine perfusion, hypothermic regional perfusion, normothermic machine perfusion, normothermic regional perfusion, sub-normothermic machine perfusion and sub-normothermic regional perfusion [40].
- Continuous pulsatile HMP seems to be a good preservation method for marginal organs, either initially or after a period of simple CS (shipping of suboptimal kidneys) [46].
- Some evidence shows that hypothermic dynamic preservation should be controlled by pressure and not flow, using low pressures to avoid pressure-related injury. The perfusion solutions used are specific, and are qualitatively different to CS solution [29].
- Nonoxygenated HMP of the kidney at low perfusion pressures (20-30 mmHg) has been shown to reduce DGF [41]. The largest RCT comparing simple CS with HMP of deceased donor kidneys showed an overall reduced risk of DGF and a survival benefit, most pronounced in ECD kidneys [47]. Hypothermic machine perfusion of kidneys from type III DCD donors decreased DGF with no impact on graft survival [44].
- Hypothermic machine-perfusion reduces the risk of DGF in standard criteria DBD donor kidneys regardless of cold ischaemia time [48].
- Increased vascular resistance and high perfusate injury marker concentrations are risk factors for DGF; however, they do not justify discarding the kidney. The flow perfusion value seems to be an indicator of graft viability in uncontrolled DCD donors, particularly donors with a high creatinine level [49]. However, research is required to identify a strong and reliable measure for predicting kidney viability from machine

perfusion [32]. Perfusion parameters (renal flow and renal vascular resistance) have low predictive values and should not be used as the sole criterion to assess viability of kidney grafts [50].

- The effect of oxygenated HMP was investigated in an RCT initiated by the Consortium on Organ Preservation in Europe on type III DCD kidneys and ECD kidneys [40]. Graft loss was significantly lower after oxygenated HMP compared to HMP [51]. No significant differences between the two groups were shown for DGF, PNF and patient death. No difference in eGFR at one year was observed between HMPO vs. HMP; however, sensitivity analysis, accounting for all-cause graft failure, showed a higher eGFR in HMPO [51].
- A short period of normothermic machine perfusion (NMP) immediately prior to implantation has been shown to improve kidney graft function, replenish ATP and reduce injury in experimental models [52, 53].
- A retrospective study of normothermic regional perfusion (NRP) in uncontrolled DCD donors concluded that NRP appears to decrease graft failure when used a preconditioning technique with subsequent HMP preservation in these donors [54].
- Active research is being developed on preservation of prolonged warm-ischaemically damaged human kidneys (types I and II DCD) by *in situ* normothermic extracorporal hemoperfusion with oxygenation and leukocyte depletion before procurement [55]. Oxygen carriage is achieved by using blood depleted of leukocytes. Potential advantages of this preservation technique are reduction in ischaemia-reperfusion injury as well as the possibility of assessing organ viability.
- There is a registered RCT on pre-implantation NMP using an oxygenated, sanguineous normothermic perfusion solution (http://www.isrctn.com /ISRCTN15821205). However, kidney function can be evaluated during NMP by assessing macroscopic appearance of blood perfusion, renal blood flow and urine output [56].
- Continuous subnormothermic machine perfusion and controlled oxygenated rewarming has demonstrated improved creatinine clearance and preservation of structural integrity compared with continuous oxygenated HMP in a research setting [57].

| **Summary of evidence** | **LE** |
|---|---|
| A meta-analysis of randomised control trials comparing cold storage with hypothermic machine perfusion (HMP) of deceased donor kidneys showed a reduced risk of delayed graft function for HMP. | 1a |
| Hypothermic dynamic preservation should be controlled by pressure and not flow, using low pressures to avoid pressure-related injury. | 2a |
| Perfusion parameters (renal flow and renal vascular resistance) have low predictive values and should not be used as the sole criterion to assess viability of kidney grafts. | 2b |

| **Recommendations** | **Strength rating** |
|---|---|
| Minimise ischaemia times. | Strong |
| Use hypothermic machine-perfusion (where available) in deceased donor kidneys to reduce delayed graft function. | Strong |
| Hypothermic machine-perfusion may be used in standard criteria deceased donor kidneys. | Strong |
| Use low pressure values in hypothermic machine perfusion preservation. | Strong |
| Hypothermic machine-perfusion must be continuous and controlled by pressure and not flow. | Strong |
| Do not discard grafts based only on increased vascular resistance and high perfusate injury marker concentrations during hypothermic machine perfusion preservation. | Weak |

#### *3.1.3 **Donor Kidney biopsies***

Donor kidney biopsies can serve different purposes including:

- histological assessment of organ quality prior to transplantation (often referred to as procurement or harvest biopsies);
- histological analysis of focal lesions, especially if there is a suspicion of neoplasia;
- detection of donor derived lesions as reference for subsequent post-transplant biopsies (often referred to as baseline, zero-time or implantation biopsies).

#### *3.1.3.1 Procurement Biopsies*

##### 3.1.3.1.1 Background and prognostic value

Procurement biopsies are used for the detection of tissue injury to aid the decision of whether or not a deceased donor kidney is suitable for transplantation. These biopsies are most commonly performed in donors with clinical suspicion of chronic kidney injury (ECDs) [58].

Kidney discard in Europe is rarely based on histology findings [59], as procurement biopsies are not regularly performed for graft allocation in the Eurotransplant region [58]. However, since biopsy findings are the most frequent cause for discarding donor organs in the United States [60-63], their prognostic value has been analysed in numerous studies. A recently published systematic review of studies on donor kidney biopsies revealed a lack of prospective studies and marked heterogeneity regarding the type of lesions being assessed, their scoring, the definitions of post-transplant outcomes and the statistical methods employed [64]. Therefore, the published evidence suggests that the use of procurement biopsies for deciding on suitability for transplantation of donor kidneys may have some important limitations including the following [58, 64, 65]:

- *There is no consistent association between histological lesions observed in donor kidney biopsies and post-transplant outcomes.*

The concept of procurement biopsies in elderly donors was introduced by a study from Gaber *et al.,* in 1995. This study observed significantly worse outcomes in recipients of kidneys with > 20% globally sclerotic glomeruli [66]. However, subsequent studies yielded highly variable results and it cannot be concluded that glomerulosclerosis is independently associated with graft outcomes [64]. A similar variability was also observed for other potentially relevant lesions like arterial injury, interstitial fibrosis and tubular atrophy with each showing predictive value in some studies, but not in others [64].

- *There is no agreement on prognostically relevant lesions and how they should be scored.*

Specific grading systems for donor kidney biopsies have not yet been developed. Lesion scoring in pre-transplant biopsies is mostly based on the Banff consensus for post-transplant renal allograft pathology, which is supported by the 2007 Banff Conference report [67].

Many attempts have been made to use composite semi-quantitative scoring systems to express the global extent of tissue injury in donor kidney biopsies. These scoring systems are mostly based on simple addition of the Banff scores for individual lesions, most commonly glomerulosclerosis, arteriolar hyalinosis, arterial intimal fibrosis, interstitial fibrosis and tubular atrophy and rarely include clinical parameters like donor age [68], serum creatinine values and donor hypertension [69].

A limited number of histological scoring systems are based on modelling analysis [68-72]. Only the Maryland Aggregate Pathology Index (MAPI) [72] scoring system and the Leuven donor risk score [68], use graft failure as their endpoint and have been independently validated in a second cohort. Other studies used surrogate clinical endpoints like DGF [70] and estimated glomerular filtration rate (eGFR) at three months [71] to calculate histological models. In addition, these models were not validated in independent cohorts. The variation in how the components are weighted to achieve the composite score and the different endpoints used may explain the conflicting conclusions in the literature [58, 64, 65].

- *Due to the time constraints of organ allocation procurement biopsies are mostly read on frozen sections by on-call pathologists, which might affect the diagnostic reliability of reported findings.*

This may have substantial impact on the diagnostic reliability of the procedure since frozen sections are prone to morphological artefacts that can impair the detection and scoring of potentially important lesions such as arteriolar hyalinosis and interstitial fibrosis [73, 74]. There is strong evidence that dedicated renal pathologists should examine formalin-fixed paraffin-embedded core-needle biopsies. Paraffin histology employing special stains is technically superior to frozen sections since morphological details are better preserved on paraffin sections than on frozen sections and potentially confounding artefacts can be avoided. Rapid processing of tissue for paraffin histology is technically feasible, but the respective protocols are not universally implemented and are not available on a 24/7 basis in most departments. Another source of variability is the professional experience of the pathologist in charge [75]. Procurement biopsies are commonly read by the on-call general pathologist who frequently has no specific training in renal pathology. A study specifically addressing this issue found that the on-call pathologists tended to overestimate chronic injury in biopsies [76].

#### *3.1.3.2 Type and size of biopsy*

Many transplant centres obtain wedge biopsies of donor kidneys rather than needle biopsies due to the presumed higher risk of bleeding complications with the latter. Wedge biopsies sample the cortex superficially whereas needle biopsies reach deeper aspects of the cortex. Needle biopsies also allow sampling from different areas of the kidney. Submit 14 or 16 G needle biopsies as obtaining adequate biopsies with 18 G needles requires multiple cores [77]. Several studies comparing wedge with needle biopsies concluded that

needle biopsies perform much better in the evaluation of vascular lesions because interlobular arteries are rarely sampled in wedge biopsies. Both methods were comparable for glomerular or tubulointerstitial lesions [78-81]. It was also demonstrated that glomerulosclerosis is significantly more pronounced in the subcapsular zone compared with deeper areas of the cortex [82]. The problem of insufficient sampling of arteries and over representation of (subcapsular) glomerular scars in wedge biopsies, can only be avoided if particular attention is paid to the correct performance of the biopsy, with a minimal depth of 5 mm [83]. The predictive value of glomerulosclerosis increases significantly with higher numbers of glomeruli in the wedge biopsy, with ideally at least 25 glomeruli required for evaluation [80]. There is limited evidence regarding complication rates in pre-implantation biopsies.

For surgeons who are reluctant to take needle biopsies, the use of a skin punch biopsy device might be an attractive alternative. Skin punch biopsies measure 3 mm in diameter. They have a shorter length than needle biopsies therefore avoiding injury to large calibre arteries at the corticomedullary junction whilst still sampling tissue from deeper areas of the cortex [84].

*3.1.3.3 Summary of evidence and recommendations*

| **Summary of evidence** | **LE** |
|---|---|
| Individual histologic lesions like glomerulosclerosis, arterial luminal narrowing or tubulointerstitial injury observed in donor kidney biopsies have limited prognostic value for long-term allograft survival. | 3 |
| Composite histological scoring systems provide a more comprehensive measure of overall organ damage. However, published scoring systems still lack independent validation and robust thresholds. | 3 |
| Size of the biopsy is of critical importance for its diagnostic value. An adequate biopsy reaches beyond the immediate subcapsular area (≥ 5 mm) and contains ≥ 25 glomeruli and ≥ one artery. Needle biopsies, wedge biopsies or specimens obtained with a skin punch biopsy device will result in equally adequate biopsies if sampling is properly performed. Obtaining adequate biopsies with 18 G needles is difficult and requires multiple cores. | 3 |

| **Recommendations** | **Strength rating** |
|---|---|
| Do not base decisions on the acceptance of a donor organ on histological findings alone, since this might lead to an unnecessary high rate of discarded grafts. Interpret histology in context with clinical parameters of donor and recipient including perfusion parameters where available. | Strong |
| Use paraffin histology for histomorphology as it is superior to frozen sections; however, its diagnostic value has to be balanced against a potential delay of transplantation. | Strong |
| Submit 14 or 16 G needle core biopsies, wedge biopsies or skin punch biopsies for histopathology. | Weak |
| Procurement biopsies should be read by a renal pathologist or a general pathologist with specific training in kidney pathology. | Strong |

*3.1.3.4 Implantation biopsies*

Implantation biopsies are used to provide baseline information on donor kidney injury for comparison with subsequent post-transplant kidney biopsies. Baseline biopsies can be essential for clear distinction between pre-existing damage and acquired lesions. They are particularly valuable in cases of thrombotic microangiopathy, arteriolar hyalinosis or acute tubular injury. In contrast to procurement biopsies that are obtained at the time of organ harvesting, implantation biopsies are usually taken before implantation in order to cover potential effects of cold ischaemia time. Their diagnostic contribution has not been formally quantified in the literature which might be due to the difficulties of measuring the value of implantation biopsies for improving diagnoses. Despite the lack of formal studies investigating their value it seems very reasonable to perform implantation biopsies in deceased donor kidneys.

*3.1.4* ***Living and deceased donor implantation surgery***

*3.1.4.1 Anaesthetic and peri-operative aspects*

Good communication between nephrologists, anaesthetists and surgeons is required for optimal anaesthetic and peri-operative care of the renal transplant patient. Anaesthetic care of the living kidney donor [85] and renal transplant recipient [86] have been reviewed and recent guidelines from the European Renal Association-European Dialysis and Transplantation Association (ERA-EDTA) [87] are cross referenced.

*3.1.4.2 Immediate pre-op haemodialysis*

Routine use of haemodialysis immediately prior to renal transplantation is not indicated [87]. Hyperkalaemia is the most common indication for haemodialysis pre-operatively. The risks of haemodialysis compared with medical therapy must be considered along with the risks of intra-operative fluid overload, electrolyte and acid-base disturbances, particularly where a deceased donor kidney is transplanted with a significant risk of DGF. Pre-operative haemodialysis may initiate a pro-inflammatory state, delay surgery, increase the CIT and increase the risk of DGF [88].

| **Summary of evidence** | **LE** |
|---|---|
| Pre-operative haemodialysis has the potential to delay transplantation, increase cold ischaemia time and increase the risk of delayed graft function. | 2 |

| **Recommendation** | **Strength rating** |
|---|---|
| Use dialysis or conservative measures to manage fluid and electrolyte imbalance prior to transplant surgery taking into consideration the likelihood of immediate graft function. | Weak |

*3.1.4.3 Operating on patients taking anti-platelet and anti-coagulation agents*

Many patients active on the transplant waiting list have vascular disease and/or a pro-thrombotic condition that should be risk-assessed prior to transplantation. Dual anti-platelet therapy is commonly given to patients with coronary artery stents for six to twelve months; peri-operative management plans for these patients should be discussed with a cardiologist so that the risks of withdrawal of the anti-platelet agent can be fully considered. Options for reversal of anti-coagulation and post-operative anti-coagulation should be discussed with a haematologist prior to patient listing.

Some patients will be active on a transplant waiting list whilst continuing to take anti-platelet and/or anti-coagulation agents. The indication for anti-platelet or anti-coagulation agents should be clearly documented for each individual. Potential increased risk of peri-operative bleeding needs to be weighed against potential harm from arterial or venous thrombosis. In accordance with the American College of Chest Physicians and the European Society of Cardiology guidelines [89, 90], the literature suggests that continuing anti-platelet therapy with aspirin, ticlopidine or clopidogrel does not confer a significantly greater risk of peri/post-operative complications [91], however, the number of patients studied was low. If needed, the effect of anti-platelet agents can be reduced with intra-operative platelet infusions.

| **Summary of evidence** | **LE** |
|---|---|
| A retrospective single-centre case-control study in patients undergoing kidney transplantation concluded that continuing anti-platelet therapy with aspirin, ticlopidine or clopidogrel does not confer a significantly greater risk of peri/post-operative complications. | 3 |

| **Recommendations** | **Strength rating** |
|---|---|
| Consider continuing anti-platelet therapy in patients on the transplant waiting list. | Weak |
| Discuss patients who take anti-platelet and anti-coagulation agents prior to transplant surgery with relevant cardiologist/haematologist/nephrologist. | Weak |

*3.1.4.4 What measures should be taken to prevent venous thrombosis including deep vein thrombosis during and after renal transplant?*

Peri-operative administration of short-acting anti-coagulation agents reduces peri-operative risk of venous thrombosis (including in ileo-femoral and renal veins); however, due to associated increased blood loss administration requires knowledge of individual patient risk factors. None of the current major thrombosis prevention guidelines directly address thromboprophylaxis in the renal transplant peri-operative period. A small RCT [92] showed no difference in early post-operative graft loss or thromboembolic complications with or without prophylactic anti-coagulation. Those administered prophylactic anti-coagulation had significantly lower haemoglobin whilst those administered prophylactic unfractionated heparin had prolonged lymph drainage. Based on this study, routine pharmacological prophylaxis is not recommended in low-risk living donor recipients. Mechanical measures to decrease ileo-femoral deep vein thrombosis (DVT) can be used where there is no contraindication due to peripheral vascular disease particularly where there are concerns about bleeding risks with pharmacological prophylaxis.

| Summary of evidence | LE |
|---|---|
| A small RCT (n=75) showed no difference in early post-operative graft loss or thromboembolic complications with or without prophylactic anti-coagulation. | 1b |

| Recommendation | Strength rating |
|---|---|
| Do not routinely give post-operative prophylactic unfractionated or low-molecular-weight heparin to low-risk living donor transplant recipients. | Weak |

*3.1.4.5 Is there a role for peri-operative antibiotics in renal transplantation?*

Prophylactic peri-operative antibiotics are generally used in renal transplant surgery but the optimal antibiotic regimen is not known and increasing antibiotic resistance may hamper their effectiveness in this setting. A multicentre, prospective RCT showed no difference at one month in surgical site, bacterial, fungal or viral infection between those receiving a single dose broad spectrum antibiotic at induction of anaesthesia compared to those receiving antibiotic 12 hourly for three to five days [93]. A retrospective comparison of peri-operative intravenous cefazolin prophylaxis compared to no antibiotic showed no difference in infectious complications (surgical site, urinary tract, bacteraemia or central catheter-related infection) in the first month after renal transplantation [94].

| Summary of evidence | LE |
|---|---|
| A multicentre, prospective RCT showed that the incidents of surgical site infection and urinary tract infection were similar in those receiving a single dose broad spectrum antibiotic at induction of anaesthesia and those receiving antibiotic 12 hourly for three to five days. | 1b |

| Recommendation | Strength rating |
|---|---|
| Use single-dose, rather than multi-dose, peri-operative prophylactic antibiotics in routine renal transplant recipients. | Strong |

*3.1.4.6 Is there a role for specific fluid regimes during renal transplantation and central venous pressure measurement in kidney transplant recipients?*

Careful peri- and post-operative fluid balance is essential for optimal renal graft function. There is no evidence determining if crystalloids or colloids are better for intravenous fluid management during renal transplant surgery, however colloids may be immunogenic. If normal saline (0.9%) is used, monitoring for metabolic acidosis is recommended in the peri-operative period. A prospective double-blind RCT compared normal saline to lactated Ringer's solution as intra-operative intravenous fluid therapy. Serum creatinine at day three post-surgery did not differ between the two groups. However, Ringer's lactate caused less hyperkalaemia and metabolic acidosis than normal saline. Balanced solutions may be the optimal and safer option for intraoperative intravenous fluid therapy [95].

Central venous pressure (CVP) measurement helps anaesthetists guide fluid management. A small prospective non-blinded RCT compared two normal (0.9%) saline regimens: constant infusion (10-12 mL/kg-1/h-1 from start of surgery until reperfusion) and central venous pressure-based infusion (target CVP appropriate to stage of operation) [96]. Central venous pressure directed infusion produced a more stable haemodynamic profile, better diuresis and early graft function. Directed hydration may decrease DGF rates and CVP measurement may help optimise early graft function.

| Summary of evidence | LE |
|---|---|
| A small (n=51) prospective RCT found that use of Ringer's lactate solution was associated with less hyperkalaemia and acidosis compared with normal saline in patients undergoing kidney transplantation. | 1b |
| A small (n=40) prospective RCT comparing constant infusion vs. central venous pressure found that central venous pressure produced a more stable haemodynamic profile, better diuresis and early graft function. | 1b |

| Recommendations | Strength rating |
|---|---|
| Optimise pre-, peri- and post-operative hydration to improve renal graft function. | Strong |
| Use balanced crystalloid solutions for intra-operative intravenous fluid therapy. | Weak |
| Use target directed intra-operative hydration to decrease delayed graft function rates and optimise early graft function. | Strong |

*3.1.4.7 Is there a role for dopaminergic drugs, furosemide or mannitol in renal transplantation?*

Low-dose dopamine (LDD) has been used in renal transplantation due to a perceived improvement in urine output and early graft function. Use of LDD in kidney donors is outside of the scope of this section. Conflicting results prevent a consensus statement on routine use of LDD in transplant recipients. A small (n=20) prospective randomised cross-over study in deceased donor renal transplantation suggested significant improvements in urine output and creatinine clearance in the first nine hours post-surgery without adverse events [97]. By contrast, a retrospective comparison of LDD in the first twelve hours post-deceased donor renal transplantation showed no difference in diuresis or kidney function but those administered LDD (n=57) had increased heart rates, longer intensive therapy unit stay and higher six-month mortality than those not treated with LDD (n=48) [98].

Considerable variation exists in the use of diuretics during renal transplant recipient surgery and there is little evidence to suggest any benefit from their use [99]. No evidence on the use of mannitol during renal transplant recipient surgery was found during the panel's literature search. Use of mannitol in kidney donors is outside the scope of this section.

| Summary of evidence | LE |
|---|---|
| A retrospective comparative study of low-dose dopamine (LDD) treated vs. non-treated renal transplantation patients concluded that LDD administration did not improve kidney function in the first twelve hours post renal transplantation, but did result in increased heart rates, longer intensive therapy unit stay and higher six-month mortality in those receiving LDD. | 2b |

| Recommendation | Strength rating |
|---|---|
| Do not routinely use low-dose dopaminergic agents in the early post-operative period. | Weak |

*3.1.5* ***Surgical approaches for first, second, third and further transplants***

Transplant (bench/back-table) preparation is a crucial step in the transplantation process. The kidney must be inspected whilst on a sterile ice slush, removing peri-nephric fat when possible to permit inspection of the quality of the organ and to exclude exophytic renal tumours. Biopsy of the kidney on the back-table may be performed to help in the multifactorial decision-making process regarding the quality and usage of the kidney for both single and/or dual transplantation. Suspicious parenchymal lesions also require biopsy. Techniques for intra-operative kidney biopsy are discussed in section 3.1.3.

The number, quality and integrity of renal vessels and ureter(s) should be established and lymphatics at the renal hilum ligated. The quality of the intima of the donor renal artery should be evaluated. Branches of the renal artery not going to the kidney or ureter(s) should be tied.

In deceased donor kidney transplantation the quality of the aortic patch should be determined. If severe atheroma of the patch, ostium or distal renal artery is seen then the aortic patch and/or distal renal artery can be removed to provide a better quality donor renal artery for implantation. Back table reconstruction of multiple donor arteries is discussed in section 3.1.5.1. The length of the renal vein should be evaluated. Renal vein branches should be secured/tied.

For a deceased donor right kidney, lengthening the renal vein on the back table may be performed if needed with donor inferior vena cava [100]. Techniques for lengthening a short living donor right renal vein from donor gonadal vein or recipient saphenous vein require pre-operative planning and specific consent (discussed in section 3.1.5.1).

The length, quality and number of the ureter(s) should be established. The peri-pelvic and proximal peri-ureteral tissue in the 'golden triangle' should be preserved.

| Recommendation | Strength rating |
|---|---|
| Assess the utility (including inspection) of the kidney for transplantation before commencement of immunosuppression and induction of anaesthesia for deceased donor kidney transplantation. | Strong |

*3.1.5.1 Single kidney transplant - living and deceased donors*

The standard surgical approach for first or second single kidney transplant (SKT) operations remains open kidney transplant (OKT). Emerging surgical technologies using minimal access surgical approaches have been developed and the different surgical approaches (minimally invasive open, laparoscopic and robot-assisted) were compared in a systematic review [101].

An extra-peritoneal approach to either iliac fossa should be used as the operative approach in most first or second single kidney transplant (SKT) operations. There is no evidence to prefer placement of a left or right kidney into either iliac fossa [102]. Peri-iliac vessel lymphatics should be ligated to try and prevent post-operative lymphocele. Appropriate segments of iliac artery and vein should be mobilised to facilitate appropriate tension free vascular anastomoses and the final positioning of the transplanted kidney. There is evidence supporting the benefits of cooling the kidney surface during implantation [103].

| Recommendations | Strength rating |
|---|---|
| Choose either iliac fossa for placement of a first or second single kidney transplant. | Weak |
| Ligate peri-iliac vessel lymphatics (lymphostasis) to reduce post-operative lymphocele. | Weak |

A variety of techniques have been described to help with the anastomosis of a short renal vein. This is most commonly encountered with a right kidney especially from a living donor. To achieve equivalent outcomes with right kidneys appropriate surgical technical manoeuvres may be needed to optimise right kidney implantation.

A number of studies suggest marginally worse outcomes with use of the right compared to left kidney, two large registry studies demonstrate a slightly higher risk of early graft failure using right compared to left kidneys from living donors [104-106]. Registry study of 2,450 paired kidneys, donated after cardiac death, observed with right kidneys: more early surgical complications; an increased risk in DGF (Odds Ratio [OD] 1.46); and inferior one year graft survival (OD 1.62), but not at subsequent time points [105]. However, surgical techniques used to compensate for a right kidney, anastomosis time and surgeon experience were not recorded. A recent registry study of 87,112 deceased-donor kidney recipient pairs reported a modest increase in DGF (adjusted OD 1.15) and all-cause graft failure (adjusted hazard ratio 1.07), within the first six months, associated with use of the right kidney, but there was no association with recipient mortality [107]. Furthermore, data from cohort studies [101, 103] and one registry study [104] suggest equivalent outcomes with either left or right deceased donor kidneys. Meta-analysis of data from one RCT and fourteen cohort studies suggested equivalent graft outcomes [108]. Overall, these findings do not support declining an organ for kidney transplantation based on laterality of kidney offered.

Techniques to manage a short renal vein can be addressed in the donor and/or recipient. Ligation of internal iliac vein(s) may be necessary to elevate the iliac vein and avoid tension on the renal vein anastomosis [102]. Transposition of the iliac artery and vein may enhance the position for the venous anastomosis [109]. The right renal vein may be lengthened. With deceased donor kidneys this is usually done with donor inferior vena cava (IVC) [110]. In living donors, lengthening of the renal vein may be achieved with donor gonadal vein retrieved at donor nephrectomy [111] or with recipient saphenous vein [112], although both require specific consent and in general the other aforementioned techniques are preferred.

| Summary of evidence | LE |
|---|---|
| Prospective cohort studies demonstrated that:<br>• transposition of the recipient iliac vein is an appropriate technical solution to compensate for the short length of the renal vein in right kidney living-donor nephrectomy (n=43);<br>• the living donor right kidney renal vein can be successfully lengthened using donor gonadal vein (n=17) or recipient saphenous vein (n=19). | 3 |

| Recommendation | Strength rating |
|---|---|
| Assess the length of the donor renal vein and if it is short consider one of a variety of surgical techniques to optimise the venous anastomosis. | Weak |

A history suggesting previous iliac or femoral vein thrombosis should initiate pre-operative imaging to establish patency of one iliac vein and the IVC. An intra-operative finding of an unexpected iliac vein and/or vena cava thrombosis may lead to abandonment of implantation. With pre-operative planning, native renal (orthotopic) or superior mesenteric vein or gonadal vein collaterals can be used.

The external or common iliac arteries are equally good for arterial anastomosis. The internal iliac artery is more frequently affected by atherosclerosis than the external or common iliac arteries. End-to-side anastomosis of donor renal artery to recipient external and/or common iliac artery is recommended in general over an end-to-end anastomosis to the internal iliac artery. The only RCT comparing these techniques suggests no difference [113]. However, the study was limited by small numbers and a high (8%) overall renal artery thrombosis rate.

The sites of the vascular anastomosis should be chosen carefully according to the length of the renal artery and vein to avoid kinking of the vessels when the kidney is placed into its final location, usually in the iliac fossa. The site of the arterial anastomosis should avoid atheromatous plaques in the iliac artery to decrease the risk of iliac artery dissection. The intima of the donor and recipient arteries should be checked prior to commencing the arterial anastomosis to ensure that there is no intimal rupture/flap. If this is found it must be repaired prior to, or as part of, the arterial anastomosis.

A Carrel patch is usually maintained on a deceased donor renal artery although it can be removed if there is either severe ostial atheroma/stenosis (with good quality proximal renal artery) or if the length of the renal artery is too long for the appropriate implantation site on the iliac artery (which is more common with the right renal artery).

Multiple renal arteries supplying a deceased donor kidney can be maintained on a Carrel patch (of appropriate length) and implanted as a single anastomosis. In living donor transplantation, multiple renal arteries require a variety of strategies to achieve optimum re-perfusion [99]. Two arteries can be implanted separately or to achieve a single anastomosis: a very small second artery (especially if supplying the upper pole) may be sacrificed; the two arteries may be joined together (as a trouser graft); or the smaller artery can be anastomosed onto the side of the main artery (end-to-side anastomoses). A lower polar artery may be re-vascularised via anastomosis to the inferior epigastric artery [114]. In living donor transplantation where three or more donor arteries exist consideration should be given to alternate kidney donors. In circumstances using a living donor kidney with three or more donor arteries, strategies include a combination of the above techniques or, after appropriate consent, use an explanted (recipient's own) internal iliac artery graft [115] or saphenous vein graft [116].

In cases where an iliac artery prosthetic replacement has previously been carried out because of severe symptomatic iliac atheroma, the renal artery should be implanted into the prosthesis. Administration of systemic heparin should be considered prior to clamping of a vascular prosthesis [117].

A variety of sutures and suturing techniques for the vascular anastomosis are described, but in general practice, a 5/0 and 6/0 non-absorbable mono-filament polypropylene suture(s) are used for the renal vein and renal artery anastomosis. Despite this, there is no evidence to recommend one suturing technique over another to prevent, for example, transplant artery stenosis. Use of an expanded polytetrafluroethylene suture compared to standard polypropylene suture may reduce blood loss due to a better needle/thread ratio [118].

In third or further transplants the surgical approach must be planned pre-operatively so that appropriate arterial inflow and venous outflow exists with adequate space to implant the new kidney [119, 120]. Nephrectomy of an old transplant kidney may be required prior to transplantation or at the time of transplantation [119]. Mobilisation of the common or internal iliac artery, internal iliac vein or IVC may be required. An intra-peritoneal approach (via the iliac fossa or midline) may be required [121]. Rarely orthotopic transplantation is needed [119, 122].

Evidence suggests that minimising the anastomosis time and/or rewarming time results in reduced DGF [123]. The effect on long term graft function is uncertain, but may also be impacted by short anastomosis time [124].

| **Summary of evidence** | **LE** |
|---|---|
| A small RCT (n=38) comparing end-to-end anastomosis to the internal iliac artery vs. end-to-side anastomosis to the external iliac artery found that both techniques showed similar results in the post-operative period and at three-years follow-up. | 1b |
| Cohort studies have demonstrated third or further transplants are a valid therapeutic option with reasonable short- and long-term patient and graft survival. | 3 |

| Recommendations | Strength rating |
|---|---|
| Use the external or common iliac arteries for an end-to-side arterial anastomosis to donor renal artery. | Weak |
| Use an end-to-end anastomosis to the internal iliac artery as an alternative to external or common iliac arteries. | Weak |
| Check the intima of the donor and recipient arteries prior to commencing the arterial anastomosis to ensure that there is no intimal rupture/flap. If this is found it must be repaired prior to/as part of the arterial anastomosis. | Strong |
| Pre-operatively plan the surgical approach in third or further transplants, to ensure that appropriate arterial inflow and venous outflow exists with adequate space to implant the new kidney. | Strong |

*3.1.5.2 Robot-assisted kidney transplant surgery*

Robot-assisted kidney transplant (RAKT) surgery using living donor kidneys have now been evaluated in multi-centre prospective non-randomised studies (using IDEAL consortium principles) [125]. Single centre prospective non-randomised studies are on-going addressing RAKT with use of deceased donor kidneys. Both trans-peritoneal and extra-peritoneal approaches for RAKT are described. Potential advantages of RAKT may exist (decreased post-operative pain, incision length and lymphocele rate). Potential issues with RAKT are the exclusion of recipients with severe atherosclerosis or third (or further) kidney transplants, a higher than expected rate of DGF and a small number of reported early arterial thromboses despite carefully selected cases [126]. The learning curve for RAKT has been reported to be 35 cases for experienced surgeons in a retrospective multicentre series of 187 patients undergoing RAKT [127]. Complication and DGF rates decreased significantly and plateaued after the first 20 cases. The rate of Clavien- Dindo grade III/IV complications was 14% during the first ten RAKTs, but only 3% after this [127]. The rate of arterial graft thrombosis (1.6%) was comparable with that for open kidney transplant (0.5 - 3.5%) [127]. A ten year single-centre retrospective analysis of 239 obese RAKT patients concluded that RAKT can be safely performed in obese patients with minimal risk of developing a surgical site infection [128]. A graft failure rate of 7.1% was reported during follow up mostly due to acute rejection. Patient and graft survival was 95% and 93% at three years, respectively [128]. Evidence is too premature to recommend RAKT outside of appropriately mentored prospective studies.

*3.1.5.3 Dual kidney transplants*

Dual kidney transplant (DKT) is performed when the quality of a single deceased donor kidney is thought to be insufficient for appropriate long-term graft function and that the outcome with both kidneys would be better. A variety of surgical techniques have been described to implant the pair of donor kidneys [129]. These include unilateral extra-peritoneal (UEP) or intra-peritoneal (UIP) and bilateral extra-peritoneal (BEP) or intra-peritoneal (BIP) that can be via a midline [130] or two lateral incisions.

The aim of a unilateral approach is to leave the contralateral iliac fossa intact for future transplantation in the event of graft loss and to reduce CIT for the second kidney transplant [131]. The unilateral approach may require mobilisation and division of the internal iliac vein to facilitate the two renal veins to iliac vein anastomoses. Modifications of the unilateral technique include single renal artery and vein anastomoses (with bench reconstruction) to further reduce CIT for the second kidney [132-134]. Dual kidney transplant takes longer and has higher blood loss than SKT regardless of the technique used. Data suggest shorter operative time and hospital stay with UEP compared to BEP [135] but other data suggest similar outcomes from all DKT techniques. No RCT exists to recommend one technique for all patients or situations.

*En-bloc* retrieval is performed when kidneys are retrieved from children weighing < 15 kg. Depending on the size of the donor kidney and size and weight of the adult recipient(s), *en-bloc* transplantation of the two kidneys may be performed or, if appropriate, the aorta and IVC patch may be divided for SKT [136].

*3.1.5.4 Ureteric implantation in normal urinary tract*

Ureteric anastomotic techniques described for renal transplant recipients with no underlying urological abnormality include: extra (Lich-Gregoir) or intra (Leadbetter-Politano) vesical uretero-neo-cystotomy and uretero-ureterostomy using native ureter. A meta-analysis [137] of two RCTs and 24 observational studies favoured the extra-vesical Lich-Gregoir technique to an intravesical approach leading to reduced overall complications (specifically urine leak, stricture and post-operative haematuria). Fewer urinary tract infections (UTIs) were observed with the extravesical approach when compared with the intra-vesical technique in one RCT [138]. Pyelo- or uretero-ureterostomy to the ipsilateral native ureter has been described as a primary technique in recipients with non-refluxing native ureters [139]. A meta-analysis suggested ureteric stricture, obstruction, and stone formation were more common after uretero-ureterostomy whereas vesicoureteral reflux and UTIs were more common after uretero-neo-cystostomy [140].

The donor ureter should be kept as short as possible with peri-ureteric fat preserved to ensure adequate ureteric blood supply. The location on the bladder to position an extra-vesical anastomosis was shown in one small RCT to be advantageous at the posterior bladder rather than anterior position to facilitate future endoscopic manipulation if needed, and reported less hydronephrosis post stent removal [141]. In cases where donor ureter has been damaged at retrieval then pyelo-native-ureterostomy or pyelo-neo-cystotomy can be performed. Mono-filament absorbable sutures should be used for the urinary anastomosis to prevent stone formation around the suture material [142].

| **Summary of evidence** | **LE** |
|---|---|
| A meta-analysis of two RCTs and 24 observational studies favoured the extra-vesical Lich-Gregoir technique for reduced overall complications. | 1a |
| A multi-centre prospective comparison study found the incidence of overall complications was similar for pyelo- and uretero-ureteral anastomosis and that for both procedures no graft was lost due to urological complications. | 2b |

| **Recommendations** | **Strength rating** |
|---|---|
| Perform Lich-Gregoir-like extra-vesical ureteric anastomosis technique to minimise urinary tract complications in renal transplant recipients with normal urological anatomy. | Strong |
| Pyelo/uretero-ureteral anastomosis is an alternative especially for a very short or poorly vascularised transplant ureter. | Strong |

Transplant ureteric anastomosis can be performed with or without a ureteric stent. If a stent is placed a second procedure is generally required for removal. A Cochrane review [143] concluded that stents are recommended to reduce major urological complications, especially urinary leak. The optimal timing for stent removal has yet to be defined [144]. A meta-analysis of five RCTS including 568 kidney transplantation patients showed a significant reduction in UTIs for early (≤ 7 days) vs. late removal (≥ 14 days) [145]. No significant differences where observed between the two groups in relation to post-operative complications such as ureteral stricture, ureteral obstruction, and ureteral leakage [145]. A second meta-analysis including 3,612 patients also reported a significant reduction in UTIs with early stent removal (< 3 weeks) vs. late removal (> 3 weeks) [146]. No significant differences where observed between the two groups regarding the incidents of ureteral stenosis and ureteral leakage [146].

Most commonly, stents are removed with local anaesthetic flexible cystoscopy unless there is a need to combine with another procedure warranting general anaesthetic. Various techniques to reduce the morbidity of a second procedure involve tying the stent to the catheter or use of percutaneous stents [147].

| **Recommendation** | **Strength rating** |
|---|---|
| Use transplant ureteric stents prophylactically to prevent major urinary complications. | Strong |

Duplex ureters are not infrequently identified at organ retrieval/kidney benching or during work-up for LDN [148, 149]. Duplex ureters can be anastomosed together and then joined to the bladder as one unit (double pant) or kept as two separate anastomoses. This also applies to the two single ureters in DKT in adults or with *en-bloc* transplantation from paediatric donors. The arguments for two separate ureteric anastomoses to the bladder are that an already tenuous blood supply may be further compromised with added suturing and handling, and if there is an issue with one ureter the other should remain unaffected. The advantages to forming one single (two ureter) anastomosis to the bladder are that only one cystotomy is needed; it may be faster and complications may be reduced. There is a lack of high quality evidence relating to duplex ureters.

| **Recommendation** | **Strength rating** |
|---|---|
| Use the same surgical principals for single ureters to manage duplex ureters and anastomose them either separately or combined. | Strong |

#### *3.1.5.5 Transplantation/ureteric implantation in abnormal urogenital tract*

The following points should be considered when performing kidney transplantation in the abnormal urogenital tract:

- In patients with an ileal conduit, a kidney transplant may be placed upside down to align the ureter to the conduit and avoid a redundant ureter [150].
- The technique used to implant transplant ureter(s) into an ileal conduit is the same as the method used with native ureter(s) (Bricker; Wallace).
- In bladder augmentation or continent pouches, ureters should be implanted with a tunnel technique or extra-vesically (Lich-Gregoir). The latter is favoured in most patients.
- In patients with a Mitrofanoff catheterisable stoma or continent ileo-caecal pouch with catheterisable stoma, consideration should be given to the positioning of the catheterisable stoma (umbilical or iliac fossa - usually right-side) with clear communication with the transplant surgeons so that the position of any future transplant kidney is not compromised. If an intra-peritoneal placement of a future kidney transplant is likely, then placement of a Mitrofanoff exiting in the iliac fossa is preferable at the umbilicus. If a future kidney transplant is likely in the right iliac fossa then placement of a Mitrofanoff exiting at the umbilicus or left iliac fossa may be preferable.

### *3.1.6 **Donor complications***

Living-donor nephrectomy, like any other intervention, is potentially associated with complications and mortality. However, the fact that the operation is performed on a healthy individual amplifies the relevance of any complications. Potential complications should be included in the process of informed consent.

Reported surgical mortality is 0.01% to 0.03% with no apparent alteration due to changes in surgical techniques or donor selection in recent years [151, 152]. According to a recent systematic review (190 studies) and meta-analysis (41 studies) on complications in minimally invasive LDN, reporting on a total of 32,308 LDNs, intra-operative complications occur in 2.2% (the most common being bleeding in 1.5% and injury to other organs in 0.8%) and post-operative complications occur in 7% (infectious complications in 2.6% and bleeding in 1%) [151]. Conversion to open surgery was reported in 1.1%, half due to bleeding and half due to injury to other organs. Surgical re-interventions occurred in 0.6%; the majority due to bleeding or to evacuate a haematoma [151]. A low trigger for conversion or re-operation should be observed in order to minimise the risk of serious complications.

A review looked for complications in 14,964 LDNs performed in the U.S. from 2008-2012 and found an overall peri-operative complication rate of 16.8%, gastrointestinal (4.4%), bleeding (3.0%), respiratory (2.5%), surgical/anaesthesia-related injuries (2.4%), and “other” complications (6.6%). Among the sample, 2.4% required intensive care and in-hospital mortality was 0.007% [12].

Major Clavien Classification of Surgical Complications grade IV or higher affected 2.5% of donors. Risk factors for Clavien grade IV or higher events included obesity (adjusted odds ratio [aOR] 1.55, $p = 0.0005$), pre-donation haematologic (aOR 2.78, $p = 0.0002$), psychiatric conditions (aOR 1.45, $p = 0.04$) and robotic nephrectomy (aOR 2.07, $p = 0.002$). An annual centre volume > 50 (aOR 0.55, $p < 0.0001$) was associated with lower risk [12].

#### *3.1.6.1 Long-term complications*

Long-term complications are mostly related to the single-kidney condition. Renal function in living donors decreases after donation before improving for many years; however, in the long run it shows signs of slight deterioration [153-155]. There is a steady increase in the incidence of proteinuria; hypertension post-transplant having been shown as the main cause of increased albumin excretion [156]. A meta-analysis found that obesity (BMI > 30) is associated with a significantly lower eGFR and higher blood pressure and proteinuria one year after donation [157]. A study looking at the Norwegian Living Kidney Donor Registry found an increased long-term risk of ischaemic heart disease in live kidney donors when compared with a healthy control group eligible to be donors [158].

The overall incidence of end-stage renal disease (ESRD) (0.4-1.1%) does not differ from the general population [153, 154, 159, 160]. According to a large retrospective study, the majority of ESRD developing after living kidney donation is due to new-onset disease that would have affected both kidneys [161]. However, there are some identified risk factors for deterioration of renal function after donation. According to a study that evaluated 119,769 live kidney donors in the United States, obese (BMI > 30) living kidney donors have a 1.9-fold higher risk for ESRD compared to their non-obese counterparts [162]. Long-term risk of death is no higher than for an age- and co-morbidity-matched population [152, 159].

Health related quality of life (HRQoL), including mental condition, remains on average better than the general population after donation [159, 160, 163]. However, some donors experience significant deterioration in their perceived QoL [163]. While global HRQoL is comparable or superior to population normative data, some factors identifiable around time of donation including longer recovery, financial stressors, younger age, higher BMI, lower education, smoking and higher expectations prior to donation, may identify donors more likely to develop poor HRQoL, providing an opportunity for intervention [159, 160, 163]. It is paramount that a careful risk–benefit assessment is done and that proper information is given to the prospective donor, this should also include recommendations on health-promoting behaviour post-donation [164].

| **Summary of evidence** | **LE** |
|---|---|
| A systematic review and meta-analysis on complications in minimally invasive living donor nephrectomy concluded that the techniques used for minimally invasive living donor nephrectomy are safe and associated with low complication rates. | 1a |
| Survival rates and risk of end-stage renal disease are similar to those in the general population whilst donors HRQoL remains on average better than the general population. | 2b |

| **Recommendations** | **Strength rating** |
|---|---|
| Restrict living donor nephrectomy to specialised centres. | Strong |
| Offer long-term follow-up to all living kidney donors. | Strong |

### *3.1.7 **Recipient complications***

#### *3.1.7.1 General complications*

Surgical complications during and after kidney transplantation may expose the recipient to an increased risk of morbidity and mortality. The incidence and management of such complications is therefore of primary importance [137, 144, 165-177]. We herein describe in detail the most common surgical complications in renal transplantation.

#### *3.1.7.2 Haemorrhage*

Haematomas are usually a minor complication in renal transplantation. Their incidence is reported to be between 0.2-25% [178, 179]. Small and asymptomatic haematomas do not usually require any intervention. In case of larger haematomas, clinical signs and symptoms due to external pressure with graft dysfunction and/or thrombotic graft vessel complications can be present. These cases may be treated by percutaneous drainage under computed tomography (CT) or ultrasound (US) guidance or may require surgical treatment [178].

#### *3.1.7.3 Arterial thrombosis*

Transplant renal artery thrombosis is a rare complication with a prevalence ranging from 0.5-3.5% [180]. Usually, it is a consequence of a technical error during the anastomosis although other causes may be related to both the donor and recipient's artery condition (i.e. atherosclerosis), intimal rupture during kidney harvesting, acute rejection episodes, external compression by haematoma or lymphocele, hypercoagulative state, severe hypotension, and toxicity of immunosuppressive agents (cyclosporine or sirolimus) [181]. The clinical manifestations are acute reduction of urine output and the elevation of renal function tests, often resulting in graft loss [178]. The diagnosis is obtained with eco-colour-Doppler [178]. Surgical exploration is usually recommended to evaluate the status of the graft. In the rare event the graft appears salvageable, a thrombectomy must be performed. In this situation, the iliac artery is clamped and an arteriotomy vs. a dissection of the vascular anastomosis must be performed in order to remove the clot. The graft can be flushed in-situ and re-vascularised [178]. Unfortunately, in the majority of the situations, the graft is not perfused and therefore an allograft nephrectomy must be performed [178, 182]. Alternatively, thrombolytic agent administration through a catheter directly into the transplant renal artery can be an efficient treatment, after the first ten to fourteen post-transplantation days [178].

| **Summary of evidence** | **LE** |
|---|---|
| The diagnosis of renal artery thrombosis depends on eco-colour-Doppler followed by surgical exploration to assess the status of the graft. | 2b |
| Thrombectomy in the case of a viable graft and allograft nephrectomy in the case a non-viable graft are the treatment options for renal artery thrombosis. | 2b |

| Recommendations | Strength rating |
|---|---|
| Perform ultrasound-colour-Doppler in case of suspected graft thrombosis. | Strong |
| Perform surgical exploration in case of ultrasound finding of poor graft perfusion. | Strong |
| Perform a surgical thrombectomy in case of a salvageable graft if arterial thrombosis is confirmed intra-operatively. | Weak |
| Perform an allograft nephrectomy in case of a non-viable graft. | Strong |

*3.1.7.4 Venous thrombosis*

Transplant renal vein thrombosis is an early complication (prevalence 0.5-4%) and one of the most important causes of graft loss during the first post-operative month [183]. The aetiology includes technical errors and/or difficulties during surgery [178] and the hypercoagulative state of the recipient [184, 185]. Colour-Doppler-flow-ultrasonography shows absence of venous flow with an abnormal arterial signal (usually a plateau-like reversed diastolic flow). Furthermore, it is common to see an enlargement of the graft due to venous congestion [186]. Surgical exploration is usually recommended despite the fact that the majority of the cases will result in graft loss. In those cases where the venous thrombosis has not resulted in kidney loss at surgical exploration, a venotomy with surgical thrombectomy after clamping the iliac vein can be performed. Alternatively, an explantation and subsequent re-implantation can be considered [178]. Thrombolytic agents can also be used; however, their results have not been satisfactory [178, 187, 188].

| Summary of evidence | LE |
|---|---|
| The diagnosis of renal vein thrombosis depends on colour-Doppler-flow-ultrasonography followed by surgical exploration to assess the status of the graft. | 2b |
| Thrombectomy in the case of a viable graft and allograft nephrectomy in the case a non-viable graft are the treatment options for renal vein thrombosis. | 2b |

| Recommendations | Strength rating |
|---|---|
| Perform ultrasound-colour-Doppler in case of suspected graft thrombosis. | Strong |
| Perform surgical exploration in case of ultrasound finding of poor graft perfusion. | Weak |
| If venous thrombosis is confirmed intra-operatively, perform a surgical thrombectomy in case of a salvageable graft or an allograft nephrectomy in case of a non-viable graft. | Weak |
| Do not routinely use pharmacologic prophylaxis to prevent transplant renal vein thrombosis. | Strong |

*3.1.7.5 Transplant renal artery stenosis.*

The incidence of transplant renal artery stenosis is 1-25% [189, 190]. Risk factors include small calibre and atherosclerosis of the donor artery, trauma to donor artery at procurement, absence of arterial patch, suturing technique (interrupted vs. continuous), and damage to the iliac artery during transplantation [191, 192]. It is more common at the site of the anastomosis [191, 192]. It can be suspected in case of arterial hypertension refractory to medical treatment and/or an increase in serum creatinine without hydronephrosis or urinary infection (30). The diagnosis is performed by US-colour-Doppler, showing a peak systolic velocity (PSV) of > 200 cm/s in the graft renal artery [191]. In cases of doubt a magnetic resonance angiogram or a CT angiogram can be performed [193]. It is important to determine whether the stenosis is haemodynamically significant or not. Usually, a stenosis of over 50% is considered a risk for kidney impairment [194]. In case of mild stenosis (< 50%) and absence of symptoms with no deterioration of the allograft, the management is normally conservative; although, a strict follow-up with US-colour-Doppler and clinical parameters has to be adopted due to the possible risk of graft failure [191]. In cases of clinically significant stenosis and/or > 50% on US-colour-Doppler, a confirmatory angiogram should be performed. If confirmed and a decision to treat is taken, treatments include percutaneous transluminal angioplasty/stent or surgical intervention. Interventional radiology is typically the first choice although patients considered unsuitable for radiological angioplasty due to recent transplant, multiple, long and narrow stenosis, or after failure of angioplasty may benefit from surgical treatment [191, 192].

| Summary of evidence | LE |
|---|---|
| Suspect transplant renal artery stenosis in case of refractory arterial hypertension and/or increasing serum creatinine without hydronephrosis/infections. | 3 |
| The diagnosis for transplant renal artery stenosis is by US-colour-Doppler, showing a peak systolic velocity (PSV) of > 200 cm/s in the graft renal artery. | 2a |
| Interventional radiology is the first-line treatment option for transplant renal artery stenosis; however, in patients considered unsuitable for radiological angioplasty surgical treatment may be considered. | 3 |

| Recommendations | Strength rating |
|---|---|
| Perform ultrasound-colour-Doppler to diagnose an arterial stenosis, in case of undetermined results on ultrasound consider a magnetic resonance or computed tomography angiogram. | Strong |
| Perform percutaneous transluminal angioplasty/stent, if feasible, as first-line treatment for an arterial stenosis. | Strong |
| Offer surgical treatment in case of recent transplant, multiple, long and narrow stenosis, or after failure of angioplasty. | Strong |

#### *3.1.7.6 Arteriovenous fistulae and pseudo-aneurysms after renal biopsy*

Percutaneous biopsy may result in arteriovenous (AV) fistulae and/or intra-renal pseudo-aneurysms in 1-18% of cases [195]. The aetiology of the AV fistula is related to the simultaneous injury of adjacent arterial and venous branches. A pseudo-aneurysm occurs when only the arterial branch is damaged. Both conditions are diagnosed with US-colour-Doppler [178]. The majority of AV fistulae are asymptomatic, resolving in one to two years spontaneously, whilst approximately 30% of them persist and become symptomatic. Typically, the symptoms are hypertension, haematuria, and graft dysfunction due to shunting between arterial and venous vessels. There is an increased risk of spontaneous rupture in case of enlarging pseudo-aneurysms. For both AV fistulae and pseudo-aneurysm, angiographic selective or super selective embolisation represents the treatment of choice [196]. Partial or radical allograft nephrectomy is currently considered the last option [178].

| Recommendations | Strength rating |
|---|---|
| Perform a ultrasound-colour-Doppler if a arteriovenous fistulae or pseudo-aneurysm is suspected. | Strong |
| Perform angiographic embolisation as first-line treatment in symptomatic cases of arteriovenous fistulae or pseudo-aneurysm. | Strong |

#### *3.1.7.7 Lymphocele*

Lymphocele is a relatively common (1-26%) complication [197]. There is a significant aetiological association with diabetes, mammalian target of rapamycin (mTOR) inhibitors (i.e sirolimus) therapy, and acute rejection [198]. For large and symptomatic lymphocele, laparoscopic fenestration is associated with the lowest overall recurrence (8%) and complication (14%) rate compared to open surgery and aspiration therapy [199]. Placement of a percutaneous drain (i.e. Pig-Tail) is an option with a success rate as high as 50% [163]. Percutaneous aspiration can be performed although the recurrence rate can be as high as 95% [199], with an increased risk of local infection (6-17%) [199]. Furthermore, sclerosant agents such as ethanol, fibrin sealant, gentamicin, or octreotide reduce the recurrence rate compared to simple aspiration [199, 200].

| Recommendations | Strength rating |
|---|---|
| Perform percutaneous drainage placement as the first treatment for large and symptomatic lymphocele. | Strong |
| Perform fenestration when percutaneous treatments fail. | Strong |

#### *3.1.7.8 Urinary leak*

Urinary leakage occurs in 0-9.3% of cases [201]. Anastomotic urine leaks can be ureteral or vesical [202]. Ureteral necrosis and/or suture failure are the most important causes [203, 204]. Non-technical risk factors include recipient age, number of renal arteries, site of arterial anastomosis, occurrence of acute rejection episodes, bladder problems, and immunosuppressive regimen [205]. Urinary leak can be suspected by the urine output and the creatinine level in the drain fluid [203]. In order to decrease the risk of ureteral necrosis, it is important to preserve vascularisation of the distal ureter [203]. Furthermore, the routine use of a JJ-stent is

recommended [204, 206]. The management of urinary leak depends on the location (renal pelvis, proximal or distal ureter, and bladder), the time of appearance and the volume of the leak. For early and low volume urine leaks the treatment may be conservative (i.e. urethral catheter, percutaneous nephrostomy and JJ-stent) [207]. In case of failure of the conservative management, or massive leak, surgical repair must be undertaken. Ureteral re-implantation directly to the bladder or to the native ureter provide similar results [140, 207].

| **Summary of evidence** | **LE** |
|---|---|
| Suspect urinary leakage based on the urine output and the creatinine level in the drain fluid. | 3 |
| For early and low volume urine leaks conservative management may be considered. | 3 |
| Surgical repair should be undertaken when conservative management fails or massive urine leak occurs. | 2b |

| **Recommendations** | **Strength rating** |
|---|---|
| Manage urine leak by JJ-stent and bladder catheter and/or percutaneous nephrostomy tube. | Strong |
| Perform surgical repair in cases of failure of conservative management. | Strong |

*3.1.7.9 Ureteral stenosis*

Ureteral stenosis is a common complication in recipients, with an incidence of 0.6-10.5% [208]. Early stenosis (within three months of surgery) is usually caused by surgical technique or compromised ureteral blood supply during surgery. Late stenosis (after > six months) is provoked by infection, fibrosis, progressive vascular disease and/or rejection [203, 209]. Clinically significant ureteral stricture should be considered when persistent hydronephrosis on US occurs in association with impaired renal function. The first approach in the management of stricture is the placement of a percutaneous nephrostomy tube with an antegrade pyelogram [208]. The following treatment options depend mainly on the timing, recoverable kidney function, anatomy of the stricture, patient body habitus/comorbidities, and surgeon preference. Strictures < 3 cm in length may be treated endoscopically either with percutaneous balloon dilation or antegrade flexible ureteroscopy and holmium laser incision. In this scenario the success rate approaches 50%; although, maximum success is obtained for strictures < 1 cm [210-212]. In case of a recurrence after a primary endourological approach and/or stricture > 3 cm in length, surgical reconstruction should be performed [209] including direct ureteral re-implantation, pyelo-vesical re-implantation (with or without psoas hitch and/or Boari Flap) or in cases with a normal native ureter, uretero-ureterostomy [213, 214]. Long-term graft and patient survival are not significantly affected [215].

| **Summary of evidence** | **LE** |
|---|---|
| Clinically significant ureteral stricture should be considered when persistent hydronephrosis on US occurs in association with impaired renal function. | 3 |
| The first approach in the management of a stricture is the placement of a percutaneous nephrostomy tube with an antegrade pyelogram. | 2b |
| Strictures < 3 cm in length may be treated endoscopically. | 3 |
| For strictures > 3 cm in length or those which have reoccurred following a primary endourological approach surgical reconstruction should be performed. | 2b |

| **Recommendations** | **Strength rating** |
|---|---|
| In case of ureteral stricture, place a nephrostomy tube for both kidney decompression and stricture diagnosis via an antegrade pyelogram. | Strong |
| Manage strictures < 3 cm in length either with surgical reconstruction or endoscopically (percutaneous balloon dilation or antegrade flexible ureteroscopy and holmium laser incision). | Strong |
| Treat late stricture recurrence and/or stricture > 3 cm in length with surgical reconstruction in appropriate recipients. | Strong |

#### *3.1.7.10 Haematuria*

The incidence of haematuria ranges from 1-34% [201]. According to the literature, the Lich-Gregoire technique provides the lowest incidence of haematuria. Furthermore, meticulous haemostasis during re-implantation results in minimal bleeding [137, 201, 202]. Bladder irrigation is the first-line treatment. Some cases require cystoscopy with evacuation of clots and/or fulguration of bleeding sites [201].

#### *3.1.7.11 Reflux and acute pyelonephritis*

The frequency of vesicoureteral reflux is between 1-86% [201, 216]. Acute graft pyelonephritis occurs in 13% of graft recipients. Patients with lower tract urinary infections and cytomegalovirus (CMV) infection present a higher risk of acute graft pyelonephritis [217]. Endoscopic injection of dextranomer/hyaluronic acid copolymer may be the first approach for treatment of vesicoureteral reflux associated with acute pyelonephritis, with a success rate ranging from 57.9% after the first injection to 78.9% after the second injection [218]. Ureteral re-implantation or pyelo-ureterostomy with the native ureter is a viable second treatment option [213].

| **Recommendation** | **Strength rating** |
|---|---|
| Use an endoscopic approach as first-line treatment for symptomatic reflux. | Weak |

#### *3.1.7.12 Kidney stones*

Urolithiasis occurs in 0.2-1.7% of recipients [219, 220]. The most frequent causes are hyper filtration, renal tubular acidosis, recurrent UTIs, hypocitraturia, hyperuricaemia, hyperuricemia, excessive alkaline urine, persistent tertiary hyperparathyroidism and ureteral strictures [221, 222]. Another risk factor can be urinary anastomosis, with the lowest stone rate using Lich-Gregoir technique [220]. The most frequent clinical signs are fever, increased serum creatinine level, decreased urine output, and haematuria. Pain is usually not referred to due to impaired innervation. A US examination usually provides the diagnosis although a CT of the kidneys, ureters and bladder may be needed to confirm the location and size of the stone [221]. The management depends on the location and size of the stone, and the presence of obstruction. In case of obstructive stones first-line treatment includes placement of a nephrostomy tube, or in some occasions a JJ-stent [223]. Extracorporeal shock wave lithotripsy (ESWL) is usually considered the first approach for stones < 15 mm with stone-free rates varying between 40 and 80% depending on the location of the stone [223]. Ureteroscopy, including antegrade and retrograde approaches, can be considered for stones < 20 mm, with a success rate of up to 67% [139, 220, 224]. For larger stones (> 20 mm), percutaneous nephrolithotomy (PNL) can be offered with high overall effective stone-free rates. In cases of large impacted stones, uretero-ureteral anastomosis, pyelo-ureteral anastomosis, or uretero-vesical re-implantation may provide excellent results for both stone and ureteral obstruction [220].

| **Summary of evidence** | **LE** |
|---|---|
| Extracorporeal shockwave lithotripsy should be considered as the first-line treatment option for stones < 15 mm. | 2b |
| Antegrade/retrograde ureteroscopy and percutaneous nephrolithotomy may be considered as treatment options as they provide high stone-free rates. | 2b |
| For larger stones (> 20 mm), percutaneous nephrolithotomy can be offered with a high overall effective stone-free rate. | 2b |

| **Recommendations** | **Strength rating** |
|---|---|
| Evaluate the causes of urolithiasis in the recipient. | Strong |
| Treat ureteral obstruction due to a stone with a percutaneous nephrostomy tube or JJ-stent placement. | Strong |
| Perform shockwave lithotripsy or antegrade/retrograde ureteroscopy for stones < 15 mm. | Strong |
| Perform percutaneous nephrolithotomy for stones > 20 mm. | Weak |

#### *3.1.7.13 Wound infection*

Wound infections occur in about 4% of cases. Risk factors include recipients > 60 years, high BMI, anaemia, hypo-albuminemia, long surgical times (> 200 min) [225]. Bacteria commonly involved are *Enterobacteriaceae, Staphylococcus aureus* and *Pseudomonas* [213]. Subcutaneous sutures, pre-dialysis transplantation, sealing or ligation of lymphatic trunks, prophylactic fenestration, reducing corticosteroid load, and avoiding sirolimus/everolimus therapy can decrease wound complication rates [225].

*3.1.7.14 Incisional hernia*

Incisional hernia occurs in approximately 4% of open kidney transplantations. Risk factors include age, obesity, diabetes, haematoma, rejection, re-operation through the same transplant incision and use of m-TOR inhibitors. Mesh infection is a risk factor for incisional hernia recurrence [226]. Open and laparoscopic repair approaches are safe and effective [226].

### *3.1.8* ***Urological malignancy and renal transplantation***

The following section is limited to a synopsis of three systematic reviews conducted by the EAU Renal Transplantation Panel.

#### *3.1.8.1 Malignancy prior to renal transplantation*

3.1.8.1.1 In the recipient

Standard procedure for transplant candidates includes systematic screening for the presence of any active/latent cancer or a past history of cancer. In candidates with a previous history of urological cancer, it can be challenging to decide if patients are suitable for transplantation and if so how long the waiting period prior to transplantation should be. To date, the waiting period has been primarily based on the Cincinnati Registry, which takes into account the type of tumour and the time between its treatment and kidney transplantation. However, the Cincinnati Registry has potential drawbacks as it does not consider the epidemiology of tumours or that diagnostic and therapeutic procedures/tests have changed over time and that prognostic tools have improved. Additionally, treatment and the staging of the disease are not defined.

According to a recent systematic review the risk of tumour recurrence was similar between transplantation (n=786) and dialysis (n=1,733) populations for renal cell carcinoma (RCC) and prostate cancer (PCa). This was especially true for low grade/stage PCa, for which the risk of recurrence was low and consistent with nomograms [227]. For low stage/grade RCC the recurrence rate was significant for both dialysis and renal transplantation; however, recurrences were actually contralateral RCC with no impact on patient or graft survival [227].

Testicular cancer had a low risk of recurrence but case reports highlighted the possibility of late recurrence even for stage I tumours [227].

For urothelial carcinoma, studies were mainly related to upper urinary tract carcinomas in the context of aristolochic acid nephropathy for which the rate of synchronous bilateral tumour was 10-16% and the rate of contralateral recurrence was 31-39% [227].

These findings imply that a kidney transplant candidate with a history of appropriately treated low stage/grade PCa (PSA ≤ 10, Gleason score ≤ 6 and T1/T2a) or low grade T1 RCC could be listed for renal transplantation without any additional delay compared to a cancer-free patient. However, as the level of evidence was low, more studies are needed to standardise waiting periods before renal transplantation.

| **Summary of evidence** | **LE** |
|---|---|
| **Renal Cell Carcinoma** | |
| The recurrence rates for transplanted vs. dialysed patients at <1, 1–5, and > 5 years were 0–8% vs. 0%, 0–27% vs. 0–9% and 0–41% vs. 0–48%, respectively. | 2b |
| Overall five year survival rates for transplantation vs dialysed patients were 80–100% vs. 76–100%, respectively. | |
| **Prostate Cancer** | |
| The recurrence rates for transplantation patients at <1 and > 5 years were 0–9% and 4–20%, respectively. | 2b |
| Overall, 1–5 year survival rates for transplantation patients ranged from 62% to 100%. | |

| **Recommendation** | **Strength rating** |
|---|---|
| List for renal transplantation patients with a history of appropriately treated low stage/grade renal cell carcinoma or prostate cancer without additional delay. | Weak |

3.1.8.1.2 In the potential donor kidney

In the general population, RCC constitutes 3% of all malignancies, with the incidence being highest in patients aged > 60 years. The current increasing age of donors may lead to a higher number of incidental RCCs found in donor kidneys and could theoretically decrease the number of kidneys suitable for transplantation. The main surgical approach to these kidneys is ex vivo tumour excision on the back-table with an oncological margin, frozen section biopsy, bench surgery renorraphy, and finally transplantation in the conventional fashion [228].

A systematic review assessed the effectiveness and harms of using kidneys with small renal tumours, from deceased or living donors, as a source for renal transplantation and it reported that five year overall and graft survival rates were 92% and 95.6%, respectively [228]. Tumour excision was performed ex-vivo in all cases except for two (107/109 patients), and the vast majority of excised tumours were RCCs (88/109 patients), with clear-cell subtype the most common [228]. This systematic review, although with low-level evidence, suggested that kidneys with small renal masses are an acceptable source for renal transplantation and do not compromise oncological outcomes with similar functional outcomes to other donor kidneys.

| **Summary of evidence** | **LE** |
|---|---|
| Tumour excision was performed *ex-vivo* in all cases except for two (107/109 patients). | 2b |
| Overall survival rates at one, three and five years were 97.7%, 95.4%, and 92%, respectively. | |
| Mean graft survival rates at one, three and five years were 99.2%, 95%, and 95.6%, respectively. | |

| **Recommendation** | **Strength rating** |
|---|---|
| Do not discard a kidney for potential transplantation on the basis of a small renal mass alone. | Weak |

*3.1.8.2 Malignancy after renal transplantation*

Cancer development after kidney transplant has become a major problem as it is one of the main causes of death in this population. Urological cancers, have an increased incidence after kidney transplantation partly due to the increasing age of recipients and their prolonged survival after transplantation.

Treatment of localised PCa following kidney transplantation is challenging due the presence of the kidney graft in the pelvic cavity close to the prostate. Two systematic reviews reported that oncological outcomes following PCa treatment in kidney transplant recipients are comparable to the non-transplanted population [229, 230] and surgery (radical prostatectomy), carried out in tertiary high-volume referral centres was the treatment choice in 75 to 85% of patients [229, 230]. Marra *et al.,* reported cancer-specific survival rates of 96.8% for surgery, 88.2% for radiotherapy with androgen deprivation therapy and 100% for brachytherapy at mean follow-up of 24 months [230]. Hevia *et al.,* reported five year cancer-specific survival of 97.5% for surgery, 87.5% for external beam radiation and 94.4% for brachytherapy [229].

| **Summary of evidence** | **LE** |
|---|---|
| Surgery (radical prostatectomy) was the most frequently performed treatment for localised PCa after kidney transplant. | 2b |
| Overall oncological outcomes following PCa treatment in kidney transplant recipients were comparable to the non-transplanted population. | 2b |

| **Recommendations** | **Strength rating** |
|---|---|
| Be aware of the presence of a kidney transplant in the pelvis and the possibility of subsequent transplants when planning treatment for prostate cancer. | Strong |
| Refer kidney transplant patients with prostate cancer to an integrated transplant urology centre. | Strong |

*3.1.9* ***Matching of donors and recipients***

Histocompatibility antigens show remarkable polymorphism and human leukocyte antigen (HLA) matching is still very important in kidney transplantation as transplant outcome correlates with the number of HLA mismatches [231-234]. Human leukocyte antigen incompatibility can result in proliferation and activation of the recipient's CD4+ and CD8+ T-cells with concomitant activation of B-cell allo-antibody production. This may lead to cellular and humoral graft rejection. Matching should concentrate on HLA antigens, which impact

outcome. Human leukocyte antigens A, B, C as well as DR must be determined in all potential recipients and donors according to current guidelines and national allocation rules [231-236]. Additionally, it is recommended to determine HLA-DQ antigens of donor and recipient. Furthermore, HLA-DP antigen characterisation may be performed, especially for sensitised recipients [231-236].

All patients registered for renal transplantation must have their serum screened for anti-HLA antibodies, which are particularly common after pregnancy, previous transplant, transplant rejection, and blood transfusions [231-236]. Thorough pre-transplant testing for HLA antibodies must be performed according to current recommendations [231-236]. Sera from potential organ recipients should be screened for HLA-specific antibodies every three months or as stipulated by the national and/or international organ exchange organisations [231-236]. In addition, screening for HLA-specific antibodies should be carried out at two and four weeks after every immunising event, e.g. blood transfusion, transplantation, pregnancy, and graft explantation [231-236]. Highly sensitised patients should have prioritised access to special allocation programmes [233, 234, 236], such as the acceptable mismatch (AM) programme of Eurotransplant [237]. A careful analysis of HLA antibody specificities must be carried out to avoid unacceptable HLA antigens and to determine acceptable HLA antigens in potential donors, who are expected to give a negative cross-match result. The definition of unacceptable HLA antigens should be implemented according to local allocation rules and international recommendations [231-235, 238]. The information on unacceptable HLA antigens should be highlighted with the patient's details in the database of the national kidney-sharing programme, preventing the unnecessary transport of kidneys to recipients with high antibody sensitivity.

To avoid hyper-acute rejection (HAR), adequate (e.g. CDC, virtual) cross-match tests must be performed before each kidney and combined kidney/pancreas transplantation in accordance with national and international recommendations [231-234, 236].

Laboratories which provide HLA-testing, HLA antibody testing and cross-matching for transplant centres must have valid accreditation to ensure accuracy and reliability [225, 226, 231-233]. They must follow the standards of national and international organisations, such as the European Federation for Immunogenetics [236].

Previously, compatibility for ABO blood group antigens and HLA antigens was of critical importance in kidney transplantation. This may change in the future, e.g. in the new U.S. allocation system A2 and A2B donors are transplanted into B recipients [234]. To avoid an increasing imbalance between demand and supply in deceased donor kidney transplantation in O recipients, ABO identity is demanded by several organ allocation organisations with a few exceptions, e.g. as in zero HLA-A+B+DR-mismatch kidneys [234, 235]. With the introduction of antibody elimination methods, potent immunosuppression and novel agents (e.g. anti B-cell drugs), successful ABO-incompatible living donor transplantations, with good long-term outcomes are possible [239, 240]. However, higher costs and infection rates have been described.

Even the barrier of a positive cross-match due to preformed HLA antibodies is under discussion with newer "desensitisation" techniques available in cases with available living donors [241, 242]. Success rates are lower, antibody-mediated rejections are frequent, but survival may be better compared to waiting list survival on dialysis. While this is a rapidly evolving field, further research is needed to define standard protocols. Until then such "desensitisation" protocols are experimental and patients undergoing "desensitisation" should be treated in specialised centres, where outcomes are documented. Patients should be informed adequately of the risks and limitations and alternative strategies (e.g. acceptable mismatch programmes, cross-over transplantation and donor chains) should be discussed.

| **Summary of evidence** | **LE** |
|---|---|
| Human leukocyte antigen (HLA) matching is very important in kidney transplantation as transplant outcome correlates with the number of HLA mismatches. Matching should concentrate on HLA antigens, which impact outcome. | 3 |
| In accordance with national and international recommendations adequate (e.g. CDC, virtual) cross-match tests must be performed before each kidney and combined kidney/pancreas transplantation to avoid hyper-acute rejection. | 3 |

| Recommendations | Strength rating |
|---|---|
| Determine the ABO blood group and the human leukocyte antigen A, B, C and DR phenotypes for all candidates awaiting kidney transplantation. | Strong |
| Test both the donor and recipient for human leukocyte antigen DQ. Human leukocyte antigen DP testing may be performed for sensitised patients. | Strong |
| Perform thorough testing for HLA antibodies before transplantation. | Strong |
| Perform adequate cross-match tests to avoid hyper-acute rejection, before each kidney and combined kidney/pancreas transplantation. | Strong |

#### *3.1.10 Immunosuppression after kidney transplantation*

The principle underlying successful immunosuppression is 'the balance of survival'. Practitioners must prescribe a dosage of drug high enough to suppress rejection without endangering the recipient's health. Increased understanding of immune rejection has led to the development of safe modern immune suppression agents [243, 244], which suppress sensitised lymphocyte activity against a transplant. Immunosuppression is particularly important during the initial post-transplant period when there is a high incidence of early post-transplant rejection.

In later post-operative stages, 'graft adaptation' occurs, resulting in the very low rejection rates seen in maintenance patients. Rejection prophylaxis should therefore be reduced over time by steroid tapering and gradual lowering of calcineurin inhibitor (CNI) [243-245].

Non-specific side effects of immunosuppression include a higher risk of malignancy and infection, particularly opportunistic infections [243-245]. All immunosuppressants also have dose-dependent specific side effects. Current immunosuppressive protocols aim to reduce drug-specific side effects using a synergistic regimen. A truly synergistic regimen allows profound dose reductions of immunosuppressive drugs; therefore, reducing side effects whilst still maintaining efficacy due to the synergistic effects of the immunosuppressants.

The currently recommended standard initial immunosuppression regime provides excellent efficacy with good tolerability [243-246]. It is given to most patients and consists of:

- calcineurin inhibitors (preferably tacrolimus, alternatively cyclosporine);
- mycophenolate (MMF or enteric-coated mycophenolate sodium [EC-MPS]);
- steroids (prednisolone or methylprednisolone);
- induction therapy (preferably basiliximab in low and standard risk patients and anti-thymocyte globulin (ATG) in high-risk patients).

This multidrug regimen reflects the current standard of care for the majority of transplant recipients worldwide [243-245] and may be modified according to local needs and immunological risk. This standard regimen is likely to change as new immunosuppressive drugs and new treatment regimens are developed [243-245]. In addition, any initial drug regimen will need to be tailored to the individual needs of a patient as suggested by the appearance of side effects, lack of efficacy or protocol-driven requirements.

| Recommendation | Strength rating |
|---|---|
| Perform initial rejection prophylaxis with a combination therapy of a calcineurin inhibitor (preferably tacrolimus), mycophenolate, steroids and an induction agent (either basiliximab or anti-thymocyte globulin). | Strong |

##### *3.1.10.1 Calcineurin inhibitors*

Both cyclosporine and tacrolimus have significant side effects that are hazardous to the graft and patient [243-250]. Most importantly, both are nephrotoxic [251, 252], and long-term use is an important cause of chronic allograft dysfunction [253], eventually leading to graft loss or severe chronic kidney disease in recipients of non-renal organs. Both CNIs are considered to be 'critical-dose' drugs, so that any deviations from exposure can lead to severe toxicity or failure of efficacy. Because of the narrow therapeutic window and the potential for drug-to-drug interaction, CNIs should be monitored using trough levels, which provide a reasonable estimate for exposure [250].

Meta-analysis of tacrolimus and cyclosporine has demonstrated similar outcomes with respect to overall patient and graft survival [243-249, 254-256]. Tacrolimus provided better rejection prophylaxis and was associated with better graft survival, when censored for death in some analyses. Renal function was favourable for tacrolimus treated patients, in a number of number of trials [254, 257-261]. Therefore, both CNIs can be used

for the effective prevention of acute rejection, but due to higher efficacy tacrolimus is recommended by current guidelines as first-line CNI [244].

For both CNIs several different formulations are available [250, 262-270]. Tacrolimus once-daily dosing seems to be preferred by patients and is associated with better adherence and lower pharmacokinetic variability [250, 271, 272]. Precautions (e.g. close surveillance and determination of drug levels) should be instituted after conversion from one formulation to another [270, 273-277]. In case of specific side effects of a CNI (e.g. hirsutism, alopecia, gingival hyperplasia, diabetes, polyoma nephropathy) conversion to another CNI can be a successful strategy to reduce side effects [243-245, 278]. Due to differences in the efficacy and safety profile, the choice of CNI should include the individual risks and benefits for each patient.

Despite their side effects, CNIs have been a cornerstone of modern immunosuppressive regimens for more than thirty years as they have resulted in an exemplary improvement in kidney graft survival [243, 244]. Future protocols aim to minimise or even eliminate CNIs [245, 248, 250, 279-282]. However, until such strategies provide superior outcomes, CNIs remain the standard of care [243, 244, 283]. For severe CNI-related side effects, CNI withdrawal, replacement, or profound reduction may be needed [243, 245, 248, 279, 280]. Special attention should be paid to maintenance patients, who may need less CNIs than previously thought [243, 245, 250, 280, 281, 284].

| **Summary of evidence** | **LE** |
|---|---|
| Meta-analysis of tacrolimus and cyclosporine has demonstrated similar outcomes with respect to overall patient and graft survival however, tacrolimus provided better rejection prophylaxis and renal function. | 1a |
| Due to differences in the efficacy and safety profile, the choice of calcineurin inhibitor should take into account the immunological risk, characteristics, concomitant immunosuppression, and socio-economic factors of the recipient. | 1 |

| **Recommendations** | **Strength rating** |
|---|---|
| Use calcineurin inhibitors for rejection prophylaxis as they represent current best practice pending publication of long-term results using newer agents. | Strong |
| Use tacrolimus as first-line calcineurin inhibitor due to its higher efficacy. | Strong |
| Monitor blood-levels of both cyclosporine and tacrolimus to allow appropriate dose adjustment of calcineurin inhibitors. | Strong |

#### *3.1.10.2 Mycophenolates (MPA)*

The mycophenolates, MMF and EC-MPS, are based on mycophenolic acid, which inhibits inosine monophosphate dehydrogenase (IMPDH) [285-289]. This is the rate-limiting step for the synthesis of guanosine monophosphate in the *de novo* purine pathway. As the function and proliferation of lymphocytes is more dependent on *de novo* purine nucleotide synthesis compared to other cell types, IMPDH inhibitors may provide more specific lymphocyte-targeted immunosuppression. The co-administration of mycophenolate with prednisolone and CNI has resulted in a profound reduction of biopsy-proven rejections [243, 246, 285-289]. Mycophenolic acid is not nephrotoxic; however, it inhibits bone marrow function and may cause CMV infections and gastrointestinal side effects, particularly diarrhoea [243, 246, 285-289]. There is also a higher incidence of polyoma nephropathy, especially when mycophenolate is combined with tacrolimus [290].

Both MPA formulations are equally effective with an almost identical safety profile [241, 280, 283, 285-288], though some prospective studies suggest a better gastrointestinal side-effect profile for EC-MPS in patients who have suffered from MMF-related gastrointestinal complaints, although firm evidence from prospective randomised studies is lacking [285-289, 291].

Mycophenolic acid is recommended by guidelines [244]. Standard doses in combination with cyclosporine are MMF 1 g or EC-MPS 720 mg twice daily, although higher initial doses have been suggested [243, 244, 285-289]. Despite its frequent use with tacrolimus, there is insufficient evidence to support the optimal dosage for this combination [243, 285, 287, 288, 292]. Tacrolimus has no influence on MPA exposure and leads to approximately 30% higher MPA exposure compared to cyclosporine. Most transplant centres use the same starting dose as in cyclosporine-treated patients, however dose reductions are frequent, especially because of gastrointestinal side effects. Weak evidence suggests that MPA dose reductions are associated with inferior

outcomes, especially in cyclosporine treated patients [286-288, 293, 294]. Due to the high incidence of side effects, some centres perform a protocol-driven MPA dose reduction in tacrolimus treated patients [285, 287]. Regular monitoring for polyoma (BK virus) is recommended in patients given MPA combined with tacrolimus [243, 290].

Due to a higher incidence of CMV disease with MPA [289], either CMV prophylaxis or a pre-emptive strategy with regular screening for CMV viraemia should be instituted [243, 295]. Cytomegalovirus prophylaxis with antiviral medications (e.g. valganciclovir) should be used routinely in CMV positive recipients and in CMV negative recipients of CMV positive organ transplants, because prophylaxis has recently been shown to reduce CMV disease, CMV-associated mortality in solid organ transplant recipients, and leads to better long-term graft survival in kidney allograft recipients.

The benefit for MPA drug monitoring is uncertain and currently not recommended for the majority of patients [285, 287, 288, 296].

In maintenance patients, the potency of MPA can be used for successful steroid withdrawal in most patients [297] or for substantial dose reductions of nephrotoxic CNIs, which may lead to better renal function [243-246, 248, 280, 298]. Although there have been several studies of the potential for CNI-free protocols with MPA and steroids, complete CNI avoidance or withdrawal over the first three years has been associated with a substantially increased rejection risk and even worse outcomes in prospective randomised studies [243, 245, 280]. In contrast, CNI withdrawal under MPA and steroids appeared to be safe in long-term maintenance patients beyond five years post-transplant and resulted in improved renal function [243, 245, 248, 280, 298, 299].

| **Summary of evidence** | **LE** |
|---|---|
| The co-administration of mycophenolates (MPA) with prednisolone and CNI has resulted in a profound reduction of biopsy-proven rejections. | 1 |
| Both MPA formulations, MMF and EC-MPS, are equally effective with an almost identical safety profile. | 1 |
| Due to a higher incidence of cytomegalovirus (CMV) disease with MPA either CMV prophylaxis or a pre-emptive strategy with regular screening for CMV viraemia should be instituted | 1 |

| **Recommendation** | **Strength rating** |
|---|---|
| Administer mycophenolate as part of the initial immunosuppressive regimen. | Strong |

*3.1.10.3 Azathioprine*

Mycophenolate is now routinely used as a primary therapy in place of azathioprine in most units worldwide. In comparison to azathioprine, mycophenolate reduced rejection rates significantly in prospective randomised trials [243, 244, 246, 285-289]. Although a large, prospective study found that azathioprine may give acceptable results in a low-risk population [300], azathioprine is usually reserved for patients who cannot tolerate MPA [243, 244, 285, 286, 288]. When added to dual therapy with cyclosporine and steroids, a meta-analysis found no significant benefit for azathioprine with respect to major outcome parameters [301].

| **Recommendation** | **Strength rating** |
|---|---|
| Azathioprine may be used in a low-risk population as an immunosuppressive drug, especially for those intolerant to mycophenolate formulations. | Weak |

*3.1.10.4 Steroids*

Steroids have a large number of side effects [243-245, 297], especially with long-term use. Most practitioners still consider steroids (either prednisolone or methylprednisolone) to be a fundamental adjunct to primary immunosuppression, even though successful steroid withdrawal has been achieved in the vast majority of patients in many prospective, randomised trials [243, 245, 246, 297, 302, 303]. The risk of steroid withdrawal depends on the use of concomitant immuno-suppressive medication, immunological risk, ethnicity, and time after transplantation. Although the risk of rejection diminishes over time, potential benefits may be less prominent after a prolonged steroid treatment period [243-246, 297]. Recent studies suggest similar efficacy but less diabetes after early steroid withdrawal or steroid minimisation in low risk patients treated with tacrolimus, MPA and induction (either basiliximab or ATG) [304, 305].

| Recommendations | Strength rating |
|---|---|
| Initial steroid therapy should be part of immunosuppression in the peri-operative and early post-transplant period. | Strong |
| Consider steroid withdrawal in standard immunological risk patients on combination therapy with calcineurin inhibitors and mycophenolic acid after the early post-transplant period. | Weak |

*3.1.10.5 Inhibitors of the mammalian target of rapamycin (m-TOR)*

The immunosuppressants, sirolimus and everolimus, inhibit the mammalian target of rapamycin and suppress lymphocyte proliferation and differentiation [243, 279, 306-308]. They inhibit multiple intracellular pathways and block cytokine signals for T-cell proliferation. Similar effects are seen on B-cells, endothelial cells, fibroblasts, and tumour cells. Inhibitors of m-TOR are as effective as MPA when combined with CNIs in preventing rejection [243, 246, 279, 306-309]. However, m-TOR inhibitors exhibit dose-dependent bone marrow toxicity [243, 279, 306-308]. Other potential side effects include hyperlipidaemia, oedema, development of lymphoceles, wound-healing problems, pneumonitis, proteinuria, and impaired fertility. The extensive side effect profile is responsible for inferior tolerability compared to MPA and potential differences in outcome in early years, when higher doses were used [310-315].

To date, no prospective comparative studies have been carried out on the m-TOR inhibitors sirolimus and everolimus [316]. Both m-TOR inhibitors have an almost identical side effect profile and mainly differ in their pharmacokinetic properties [243, 279, 306-308, 317]. Sirolimus has a half-life of about 60 hours, is given once a day and is licensed for prophylaxis in kidney recipients only. Everolimus has a half-life of about 24 hours, is licensed for kidney, liver and heart recipients and is given twice a day. Everolimus is licenced for use with cyclosporine and can be given simultaneously with cyclosporine, while sirolimus should be given four hours after cyclosporine. The pharmacological drug-drug interaction with cyclosporine is far less relevant for tacrolimus, resulting in the need for a higher starting dose of m-TOR inhibitors in combination with tacrolimus [260, 318, 319]. Sirolimus is also licensed in combination therapy with steroids for cyclosporine withdrawal from combination therapy with cyclosporine.

Therapeutic monitoring of trough levels is recommended because of the narrow therapeutic window and the risk of drug-to-drug interactions [243, 279, 306-308, 317].

When combined with CNIs, antimicrobial prophylaxis for Pneumocystis jirovecii pneumonia should be administered for one year following transplantation, e.g. low-dose cotrimoxazole [243, 306-308]. Most importantly, combination therapy with CNIs aggravates CNI-induced nephrotoxicity, although m-TOR inhibitors themselves are non-nephrotoxic [243]. Several studies suggest less favourable outcomes and increased drug discontinuations due to adverse events for this combination, especially if CNIs are maintained at standard dosages [243, 246, 248, 260, 309, 311, 312, 320-325]. Calcineurin inhibitor dosage should therefore be substantially reduced in combination therapy with m-TOR inhibitors, which seems to have no impact on efficacy, due to the highly synergistic potential of this combination therapy [279, 306-308, 314, 317].

Several studies suggest m-TOR inhibitors cannot replace CNIs in the initial phase after transplantation due to lower efficacy and a less favourable side effect profile, particularly wound healing problems and lymphoceles [241, 243, 244, 276, 300, 301, 306, 308, 316]. Other trials suggest that m-TOR inhibitors may replace CNI at later stages, e.g. three months after transplantation, with improvements in renal function, predominately in cyclosporine treated patients [243, 245, 246, 248, 258, 279, 306-308, 311, 312, 314, 326-328]. It is unclear if there is a real benefit in comparison to patients on tacrolimus and MPA [258, 327]. However, there is an increased risk of rejection and development of HLA antibodies [243, 245, 258, 279, 329], which may be offset by the benefit of the non-nephrotoxic immunosuppression. Patients treated with m-TOR inhibitors develop less leucopenia and opportunistic viral infections, especially less CMV infections compared to MPA [260, 311, 314, 324-326, 330].

Proteinuria and poor renal function at conversion are associated with inferior outcomes [243, 245, 279, 306-308]. Conversion from CNIs is not advisable in patients with proteinuria > 800 mg/day, and a cautious and individual approach should be followed in patients with GFR < 30 mL/min.

Due to an anti-proliferative effect and a lower incidence of malignancy in m-TOR inhibitor treated patients, conversion from CNIs to m-TOR inhibitors may be beneficial for patients, who develop malignancy after transplantation, or who are at a high risk for the development of post-transplant malignancy or skin cancer [243, 245, 279, 306-308, 313-315, 331-334]. Several studies and case reports have suggested that patients with Kaposi sarcoma under CNI therapy benefit from conversion to an m-TOR inhibitor [332].

In summary, m-TOR inhibitors are not recommended as initial immunosuppressive therapy due to their side effect profile and higher discontinuation rates [244]. However, m-TOR inhibitors are a well-studied alternative treatment option.

| Summary of evidence | LE |
|---|---|
| Combination therapy with CNIs aggravates CNI-induced nephrotoxicity. Therefore, CNI dosage should be substantially reduced in combination therapy with m-TOR inhibitors, which seems to have no impact on efficacy, due to the highly synergistic potential of this combination therapy. | 1 |
| Take into consideration impaired wound healing and prophylactic surgical measures when m-TOR inhibitors are used as part of the initial immunosuppressive regimen or when patients treated with m-TOR inhibitors undergo major surgery. | 1 |
| When combined with CNIs, antimicrobial prophylaxis for *P. jirovecii* pneumonia should be administered for one year following transplantation. | 1 |
| Conversion from CNIs is not advisable in patients with proteinuria > 800 mg/day, and a cautious and individual approach should be followed in patients with GFR < 30 mL/min. | 1 |

| Recommendations | Strength rating |
|---|---|
| The m-TOR inhibitors may be used to prevent rejection in patients who are intolerant to standard therapy. | Weak |
| Significantly reduce calcineurin inhibitor dosage in a combination regimen with m-TOR inhibitors to prevent aggravated nephrotoxicity. | Strong |
| Do not convert patients with proteinuria and poor renal function to m-TOR inhibitors. | Strong |
| Monitor blood-levels of both sirolimus and everolimus to allow for appropriate dose adjustment. | Strong |

#### *3.1.10.6 Induction with Interleukin-2 receptor antibodies*

Basiliximab, a high-affinity anti-interleukin-2 (IL-2) receptor monoclonal antibody is approved for rejection prophylaxis following organ transplantation [243, 244, 246, 335-339]. Basiliximab is given before transplantation and on day four post-transplant. The drug is safe, and IL-2 receptor antibodies have been shown in RCTs to reduce the prevalence of acute cellular rejection by approximately 40% [243, 244, 246, 335-337]. Meta-analyses [246, 335-337] have confirmed the efficacy, although no positive effect on patient or graft survival could be demonstrated, large retrospective cohort studies and recent large prospective studies suggest such a benefit [243, 244, 340, 341]. Several large controlled trials support the efficacy and safety of quadruple therapy with tacrolimus, mycophenolate and steroids. Interleukin-2 receptor antibodies may allow early steroid withdrawal [297], although higher rejection rates were described in some studies. Most importantly, IL-2 receptor antibodies allow a substantial reduction in CNIs or steroids, while maintaining excellent efficacy and renal function [243-246, 304, 335-337]. Therefore, this regimen is proposed as first-line immunosuppression in patients with low to normal immunological risk [244, 341].

| Recommendation | Strength rating |
|---|---|
| Use interleukin-2 receptor antibodies for induction in patients with normal immunological risk in order to reduce incidence of acute rejection. | Weak |

#### *3.1.10.7 T-cell depleting induction therapy*

Prophylactic immunosuppression regimens in many countries, particularly the U.S., use potent T-cell depleting 'induction' treatments [243, 244, 246, 335, 340, 342-345]. Most frequently, ATG is used for prevention of rejection in immunological high-risk patients, as supported by meta-analysis [341], and recommended by guidelines [244, 346]. In addition, these potent biological agents are used for the treatment of severe, steroid resistant rejection episodes [342, 345].

Use of T-cell depleting antibodies in immunological low-risk patients has not been associated with improved long-term outcomes but with an increased risk of severe opportunistic infections and malignancy, particularly post-transplant lymphoproliferative disease [243, 244, 246, 335, 341-343]. Some centres use these agents to provide effective rejection prophylaxis in order to facilitate steroid withdrawal [304, 340, 344].

| Recommendation | Strength rating |
|---|---|
| T-cell depleting antibodies may be used for induction therapy in immunologically high-risk patients. | Weak |

*3.1.10.8 Belatacept*

Belatacept is a fusion protein, which effectively blocks the CD28 co-stimulatory pathway and thereby prevents T-cell activation [279, 347-350]. Belatacept is intravenously administered and indicated for use as part of a CNI-free regimen together with basiliximab induction, mycophenolate, and corticosteroids. Long-term data from three randomised studies of *de novo* kidney transplant recipients demonstrated better renal function versus cyclosporine-based immunosuppression, although rates and grades of acute rejection were higher for belatacept in the first year post-transplant [243, 246, 259, 279, 349-355]. In patients receiving a standard deceased or living donor kidney, better graft survival was observed, while similar graft survival rates were found with ECDs. Interestingly, belatacept-treated patients had better preserved histology and developed less donor specific antibodies (DSA) compared to cyclosporine [356]. The long-term safety profile of belatacept treated patients was similar to cyclosporine controls, less belatacept treated patients developed metabolic complications or discontinued treatment due to adverse events [347, 348]. In addition, the option of converting patients (either stable patients or due to CNI or m-TOR associated toxicity) was explored with promising initial results [347, 348, 352, 357-359]. Specific safety signals include a higher rate of post-transplant lymphoproliferative disorder (especially in Epstein-Barr virus (EBV) negative patients), more herpes infections, and tuberculosis in patients from endemic areas [279, 347-350]. Belatacept was approved in the U.S. and in Europe for EBV positive patients, but is not yet available in many countries. Additional studies are ongoing to fully explore the value of this compound.

| Recommendation | Strength rating |
|---|---|
| Belatacept may be used for immunosuppressive therapy in immunologically low-risk patients, who have a positive Epstein-Barr virus serology. | Weak |

*3.1.11* ***Immunological complications***

Immunological rejection is a common cause of early and late transplant dysfunction [244, 360-364]. There is great variation in the timing and severity of rejection episodes and how they respond to treatment. Today two main types of immunological reactions are distinguished, T-cell mediated rejections (TCMR) and antibody-mediated rejections (ABMR) [244, 360-362, 365]. Antibody-mediated rejection and TCMR may be diagnosed together, called mixed acute rejection. Antibody-mediated rejection may occur as hyperacute rejection (HAR), active rejection or chronic rejection. Chronic ABMR is considered as one of the leading causes of late graft loss.

The ultimate standard for the diagnosis of rejection is transplant biopsy [244], because it is impossible to differentiate acute rejection solely on clinical indicators from other causes of renal dysfunction (e.g. acute tubular necrosis, infection, disease recurrence or CNI nephrotoxicity). Therefore, all rejections should be verified by renal biopsy and biopsies should be classified according to the most recent Banff criteria [366], which are the basis for prognosis and treatment [242, 360, 363]. Renal transplant biopsy should be conducted preferably under US control, using an automated needle biopsy system (e.g. Tru-Cut biopsy gun) [244, 360] with a 16 G needle to assure specimen adequacy. The biopsy procedure is considered safe but complications such as bleeding and AV fistulas may occur [244, 367, 368]. The reported risk of major complications (including substantial bleeding, macroscopic haematuria with ureteric obstruction, peritonitis or graft loss) is approximately 1%. Most important contraindications are anti-coagulant therapy including anti-platelet agents and uncontrolled hypertension.

| Summary of evidence | LE |
|---|---|
| There must be routine access to US-guided biopsy of the transplant and sufficient expertise in the hospital pathology department to allow a rapid and clear-cut diagnosis of rejection or other type of allograft dysfunction. | 2 |
| Steroid treatment for rejection may start before the renal biopsy is performed. | 2 |

| Recommendations | Strength rating |
|---|---|
| Monitor transplant recipients for signs of acute rejection, particularly during the first six months post-transplant. | Strong |
| Take regular blood samples in addition to regular monitoring of urine output and ultrasound examinations in order to detect graft dysfunction during hospitalisation. | Strong |
| Immediately rule out other potential causes of graft dysfunction in cases of suspected acute rejection. An ultrasound of the kidney transplant should be performed. | Strong |
| Perform a renal biopsy, graded according to the most recent Banff criteria, in patients with suspected acute rejection episodes. | Strong |
| Only if contraindications to renal biopsy are present, can 'blind' steroid bolus therapy be given. | Strong |
| Test patients who suffer acute rejection as soon as possible for anti-HLA antibodies against the graft. | Strong |
| Reassess the immunosuppressive therapy of all patients with rejection, including patient adherence to the medication, which is of particular importance in late rejections. | Strong |

#### *3.1.11.1 Hyper-acute rejection*

Hyper-acute rejection is the most dramatic and destructive immunological attack on the graft [231, 244, 360, 361]. It results from circulating, complement-fixing IgG antibodies, specifically reactive against incompatible donor antigen, which engages with and destroys the vascular endothelium within minutes or hours after vascularisation. It occurs in ABO-incompatible grafts due to the presence of high titres of pre-existing iso-antibodies against blood group antigens. In ABO-matched grafts, HAR is mediated by anti-donor HLA IgG antibodies. With the development of the cross-match test before transplantation, HAR has become an extremely uncommon complication [231]. Imaging and histology reveals generalised infarction of the graft, which has to be treated by graft nephrectomy. Therefore, prevention is crucial, either by avoidance of high iso-antibodies against incompatible blood group antigens in case of an ABO-incompatible renal transplant and/or by performing a regular cross-match before transplantation (see section 3.1.8).

| Recommendation | Strength rating |
|---|---|
| Prevent hyper-acute rejection by adequate ABO blood group and human leukocyte antigen matching of donor and recipients. | Strong |

#### *3.1.11.2 Treatment of T-cell mediated acute rejection*

As only a few randomised trials have investigated different treatment options for this clinical problem, therapy is mainly based on empirical experience rather than on clinical evidence [244, 345, 360, 369]. Parenteral methylprednisolone (500 mg to 1 g) should be given intravenously as one pulse per day for three days. Anuria or a steep rise in the serum creatinine may indicate steroid-refractory rejection and the need for another three day course of pulsed methylprednisolone therapy [244, 360]. In addition, baseline immunosuppression should be optimised to ensure adequate drug exposure [244, 360, 369]. In severe rejection, a conversion from cyclosporine to tacrolimus and/or from azathioprine to mycophenolate is recommended [244, 360].

T-cell depleting biological agents, such as ATG may be given in severe steroid-refractory cases [244, 342, 345, 360, 369]. If biological agents are used, other immunological suppression should be adapted and daily T-cell monitoring should be considered to minimise the dose of the biological agent [342]. Before immunosuppression is intensified, especially before the use of T-cell depleting agents, the prognosis of the graft should be critically assessed against the risks of the aggravated immunosuppression. The patient should be counselled adequately.

| Recommendations | Strength rating |
|---|---|
| Use steroid bolus therapy as first-line treatment for T-cell mediated rejection in addition to ensuring adequate baseline immunosuppression. | Strong |
| In severe or steroid-resistant rejection, use intensified immunosuppression, high-dose steroid treatment, and eventually T-cell depleting agents. | Strong |

#### *3.1.11.3 Treatment of antibody mediated rejection (ABMR)*

Treatment of ABMR relies mainly on retrospective studies and empirical treatment guidelines [370]. Consensus is that it is important to classify the clinical and histological phenotype of the rejection in order to make adequate treatment decisions [370]. Important clinical factors are time of rejection (early acute < 30 days posttransplant vs. late), preformed vs. *de novo* donor-specific antibodies (DSA), and histology (active vs. chronic rejection).

For active ABMR due to pre-existing DSA treatment with a steroid bolus (at least three days of 500 mg/day) in combination with intravenous immunoglobulin (IVIG) and plasmapheresis or immune-adsorption is recommended. Intravenous immunoglobulin (IVIG) [244, 360, 371-376] may modulate and/or suppress antibody production. Intravenous immunoglobulin alone seems insufficient for effective treatment and IVIG is used today in a multimodal regimen. Dosages vary widely from 0.2-2.0 g/kg bodyweight, and no comparative studies (e.g. on the dose or optimal concomitant immunosuppression) have been published. Retrospective and prospective case series clearly suggest efficacy of antibody removal using plasmapheresis or immune-adsorption columns [244, 360, 371-376], although details of the procedures vary widely. Adjunctive therapies such as complement inhibitors, rituximab or splenectomy might be considered in severe early acute cases. Despite controversial data on the utility of anti-CD20 antibody [244, 345, 360, 371-376], rituximab may also be considered as adjunctive therapy in late active ABMR according to expert consensus. Although T-cell depleting agents such as ATG appear to have limited value they are frequently used during mixed acute rejection [241]. However, retrospective series suggests aggravated toxicity, when rituximab is combined with ATG [377], or steroids [345]. Furthermore, many centres will optimise maintenance therapy with mycophenolate and steroids and sufficient tacrolimus trough levels should be achieved [244, 360, 371-373, 376].

Chronic AMR due to pre-existent DSA has no specific treatment recommendations except for optimisation of maintenance therapy and eventually IVIG as an adjunctive treatment with a low level of evidence. In patients presenting with *de novo* DSA optimisation of maintenance immunosuppression is recommended and non-adherence should be addressed and managed accordingly. If histology shows active ABMR plasmapheresis, rituximab and IVIG can be considered as potential adjunctive agents without good evidence from clinical trials. If biopsy demonstrates pure chronic ABMR no special treatment is recommended due to lack of convincing data, except for IVIG as potential treatment option without firm evidence. Treatment for chronic ABMR appears to be less successful [360, 371, 373].

In summary, several regimens have proven some efficacy in ABMR. However, except for a beneficial effect of early antibody removal, the lack of firm evidence does not permit evidence-based recommendations for treatment. As a consequence, prevention of ABMR by adequate pre-transplant screening, regular DSA monitoring, avoidance of suboptimal immunosuppression and reinforcement of adherence are crucial [231, 360, 375, 378].

| Recommendation | Strength rating |
|---|---|
| Treatment of antibody mediated rejection should include antibody elimination. | Strong |

### *3.1.12 **Follow-up after transplantation***

Long-term graft function is of critical importance for the success of a transplant [244, 245]. Therefore, regular long-term follow-up by experienced transplant physicians is essential in order to detect complications or graft dysfunction early and reassure adherence to the immunosuppressive regimen. Complications of immunosuppression occur frequently including specific complications of the different drugs as well as over immunosuppression (namely opportunistic infections and malignancy) [244, 245]. The risk of cancer and cardiac disease is several-fold higher in transplanted patients than in the general population. Cancer is a cause of significant morbidity and mortality in the transplanted population [244, 379, 380]. Cardiovascular disease is the most frequent cause of death in renal allograft recipients [244, 381, 382]. Other important long-term problems are non-adherence [383], the development of anti-HLA antibodies, recurrence of the original disease and CNI associated nephrotoxicity [244, 245].

#### *3.1.12.1 Chronic allograft dysfunction/interstitial fibrosis and tubular atrophy*

Many patients lose their grafts due to chronic allograft dysfunction [244, 245, 384]. Histology will usually reveal a chronic process of interstitial fibrosis and tubular atrophy (IF/TA) [385]. Some patients will have immunological chronic ABMR [386], as discussed in section 3.1.11.3. Interstitial fibrosis and tubular atrophy takes months or years to develop and is heralded by proteinuria and hypertension, with a simultaneous or delayed rise in serum creatinine level over months [244, 384, 385]. It is likely that IF/TA is more common in patients who have had

early attacks of acute rejection or infection. The main differential diagnosis is chronic nephrotoxicity [387], which is common in patients receiving CNIs, and pre-existing and/or aggravated chronic kidney damage from a marginal donor kidney [244, 384, 385].

Diagnosis is by renal biopsy [244, 384]. In patients diagnosed early, particularly if there is evidence for CNI toxicity, disease progression may be slowed by conversion to a CNI-free regimen [201-203, 263, 264]. Conversion to m-TOR inhibitors is an option for patients without significant proteinuria (< 800 mg/day), but moderate renal function [243-245]. Alternatively, successful conversion to a mycophenolate based regimen has been described, especially in patients beyond the first three years post-transplant [243, 245, 280]. If there is intolerance to m-TOR inhibitors or MPA, conversion to belatacept or an azathioprine-based regimen may be successful, though the higher risk of rejection warrants close surveillance [359]. If the risk of rejection seems too high, another option is substantial reduction of CNI under the protection of MPA [245, 280].

In patients with proteinuria, intervention with an angiotensin converting enzyme inhibitor, or angiotensin II receptor blocker [244, 384] together with tight blood pressure control may slow down renal progression. Other supportive measures include the treatment of hypertension, hyperlipidaemia, diabetes, anaemia, acidosis, and bone disease [244]. However, ultimately, the patient will require another transplant (if fit enough to go on the transplant waiting list) or dialysis therapy.

| **Summary of evidence** | **LE** |
|---|---|
| Regular long-term follow-up by experienced transplant physicians is essential in order to detect complications or graft dysfunction early and reassure adherence to the immunosuppressive regimen. | 4 |
| Annual screening should include a dermatological examination, cardiovascular history and exam, tumour screening (including a nodal examination, faecal occult screening, chest x-ray, gynaecological and urological examination), and an abdominal US, including US of the native and transplanted kidney. If appropriate, further diagnostic tests should be prompted to treat or slow down the progression of any identified complication. | 4 |
| In patients diagnosed early with IF/TA, particularly if there is evidence for calcineurin inhibitor (CNI) toxicity, disease progression may be slowed by conversion to a CNI-free regimen. If the risk of rejection seems too high, another option is substantial reduction of CNI under the protection of mycophenolates. | 1 |
| Supportive measures should aim to adequately treat the consequences of chronic kidney disease (e.g. anaemia, acidosis, bone disease). | 4 |

| **Recommendations** | **Strength rating** |
|---|---|
| Provide lifelong regular post-transplant follow-up by an experienced and trained transplant specialist at least every six to twelve months. | Strong |
| Advise patients on appropriate lifestyle changes, potential complications, and the importance of adherence to their immunosuppressive regimen. | Strong |
| Regularly monitor (approximately every four to eight weeks) serum creatinine, estimated glomerular filtration rate, blood pressure, urinary protein excretion, immunosuppression and complications after renal transplantation. Changes in these parameters over time should trigger further diagnostic work-up including renal biopsy, a search for infectious causes and anti-HLA antibodies. | Strong |
| Perform an ultrasound of the graft, in case of graft dysfunction, to rule out obstruction and renal artery stenosis. | Strong |
| In patients with interstitial fibrosis and tubular atrophy undergoing calcineurin inhibitor (CNI) therapy and/or with histological signs suggestive for CNI toxicity (e.g. arteriolar hyalinosis, striped fibrosis) consider CNI reduction or withdrawal. | Strong |
| Initiate appropriate medical treatment, e.g. tight control of hypertension, diabetes, proteinuria, cardiac risk factors, infections, and other complications according to current guidelines. | Strong |

# 4. REFERENCES


1. Phillips B, *et al.* Oxford Centre for Evidence-based Medicine Levels of Evidence. Updated by Jeremy Howick March 2009. 1998.
https://www.cebm.ox.ac.uk/resources/levels-of-evidence/oxford-centre-for-evidence-based-medicine-levels-of-evidence-march-2009
2. Guyatt, G.H., *et al.* Going from evidence to recommendations. BMJ, 2008. 336: 1049.
https://pubmed.ncbi.nlm.nih.gov/18467413
3. Lennerling, A., *et al.* Living organ donation practices in Europe - results from an online survey. Transpl Int, 2013. 26: 145.
https://pubmed.ncbi.nlm.nih.gov/23198985
4. Antcliffe, D., *et al.* A meta-analysis of mini-open versus standard open and laparoscopic living donor nephrectomy. Transpl Int, 2009. 22: 463.
https://pubmed.ncbi.nlm.nih.gov/19175543
5. Greco, F., *et al.* Laparoscopic living-donor nephrectomy: analysis of the existing literature. Eur Urol, 2010. 58: 498.
https://pubmed.ncbi.nlm.nih.gov/20417024
6. Wilson, C.H., *et al.* Laparoscopic versus open nephrectomy for live kidney donors. Cochrane Database Syst Rev, 2011: CD006124.
https://pubmed.ncbi.nlm.nih.gov/22071829
7. Yuan, H., *et al.* The safety and efficacy of laparoscopic donor nephrectomy for renal transplantation: an updated meta-analysis. Transplant Proc, 2013. 45: 65.
https://pubmed.ncbi.nlm.nih.gov/23375276
8. Serrano, O.K., *et al.* Evolution of Living Donor Nephrectomy at a Single Center: Long-Term Outcomes with 4 Different Techniques in Greater Than 4000 Donors over 50 Years. Transplantation, 2016. 100: 1299.
https://pubmed.ncbi.nlm.nih.gov/610202307
9. Breda, A., *et al.* Mini-laparoscopic live donor nephrectomy with the use of 3-mm instruments and laparoscope. World J Urol, 2015. 33: 707.
https://pubmed.ncbi.nlm.nih.gov/25182807
10. Elmaraezy, A., *et al.* Should hand-assisted retroperitoneoscopic nephrectomy replace the standard laparoscopic technique for living donor nephrectomy? A meta-analysis. International Journal of Surgery, 2017. 40: 83.
https://pubmed.ncbi.nlm.nih.gov/614566997
11. Creta, M., *et al.* Donor and Recipient Outcomes following Robotic-Assisted Laparoscopic Living Donor Nephrectomy: A Systematic Review. Biomed Res Int, 2019. 2019: 1729138.
https://pubmed.ncbi.nlm.nih.gov/31143770
12. Lentine, K.L., *et al.* Perioperative Complications After Living Kidney Donation: A National Study. Am J Transplant, 2016. 16: 1848.
https://pubmed.ncbi.nlm.nih.gov/26700551
13. Wang, H., *et al.* Robot-assisted laparoscopic vs laparoscopic donor nephrectomy in renal transplantation: A meta-analysis. Clin Transplant, 2019. 33: e13451.
https://pubmed.ncbi.nlm.nih.gov/30461073
14. Autorino, R., *et al.* Laparoendoscopic single-site (LESS) vs laparoscopic living-donor nephrectomy: a systematic review and meta-analysis. BJU Int, 2015. 115: 206.
https://pubmed.ncbi.nlm.nih.gov/24588876
15. Gupta, A., *et al.* Laparoendoscopic single-site donor nephrectomy (LESS-DN) versus standard laparoscopic donor nephrectomy [Systematic Review]. Cochrane Database of Systematic Reviews, 2016. 6: 6.
https://pubmed.ncbi.nlm.nih.gov/24588876
16. Alcaraz, A., *et al.* Feasibility of transvaginal natural orifice transluminal endoscopic surgery-assisted living donor nephrectomy: is kidney vaginal delivery the approach of the future? Eur Urol, 2011. 59: 1019.
https://pubmed.ncbi.nlm.nih.gov/21458151
17. Liu, N., *et al.* Maximizing the donor pool: left versus right laparoscopic live donor nephrectomy--systematic review and meta-analysis. Int Urol Nephrol, 2014. 46: 1511.
https://pubmed.ncbi.nlm.nih.gov/24595603

18. Khalil, A., *et al.* Trends and outcomes in right vs. left living donor nephrectomy: An analysis of the OPTN/UNOS database of donor and recipient outcomes - should we be doing more right-sided nephrectomies? Clinical Transplantation, 2016. 30: 145.
https://pubmed.ncbi.nlm.nih.gov/607640149
19. Hsi, R.S., *et al.* Analysis of techniques to secure the renal hilum during laparoscopic donor nephrectomy: review of the FDA database. Urology, 2009. 74: 142.
https://pubmed.ncbi.nlm.nih.gov/19406458
20. Hsi, R.S., *et al.* Mechanisms of hemostatic failure during laparoscopic nephrectomy: review of Food and Drug Administration database. Urology, 2007. 70: 888.
https://pubmed.ncbi.nlm.nih.gov/17919695
21. Ponsky, L., *et al.* The Hem-o-lok clip is safe for laparoscopic nephrectomy: a multi-institutional review. Urology, 2008. 71: 593.
https://pubmed.ncbi.nlm.nih.gov/18295866
22. Allen, M.B., *et al.* Donor hemodynamics as a predictor of outcomes after kidney transplantation from donors after cardiac death. American Journal of Transplantation, 2016. 16: 181.
https://pubmed.ncbi.nlm.nih.gov/605992316
23. Heylen, L., *et al.* The duration of asystolic ischemia determines the risk of graft failure after circulatory-dead donor kidney transplantation: A Eurotransplant cohort study. Am J Transplant, 2018. 18: 881.
https://pubmed.ncbi.nlm.nih.gov/28980391
24. Osband, A.J., *et al.* Extraction Time of Kidneys from Deceased Donors and Impact on Outcomes. American Journal of Transplantation, 2016. 16: 700.
https://pubmed.ncbi.nlm.nih.gov/606702054
25. Redfield, R.R., *et al.* Predictors and outcomes of delayed graft function after living-donor kidney transplantation. Transpl Int, 2016. 29: 81.
https://pubmed.ncbi.nlm.nih.gov/26432507
26. Irish, W.D., *et al.* A risk prediction model for delayed graft function in the current era of deceased donor renal transplantation. Am J Transplant, 2010. 10: 2279.
https://pubmed.ncbi.nlm.nih.gov/20883559
27. de Boer, J., *et al.* Eurotransplant randomized multicenter kidney graft preservation study comparing HTK with UW and Euro-Collins. Transpl Int, 1999. 12: 447.
https://pubmed.ncbi.nlm.nih.gov/10654357
28. Parsons, R.F., *et al.* Preservation solutions for static cold storage of abdominal allografts: which is best? Curr Opin Organ Transplant, 2014. 19: 100.
https://pubmed.ncbi.nlm.nih.gov/24553501
29. Tillou, X., *et al.* Comparison of UW and Celsior: long-term results in kidney transplantation. Ann Transplant, 2013. 18: 146.
https://pubmed.ncbi.nlm.nih.gov/23792514
30. Barnett, D., Black, D. W., Buckley, B., Campbell, D., Clarke, P.,. Machine perfusion systems and cold static storage of kidneys from deceased donors. NICE Guidelines. Technology appraisal guidance 2009.
https://www.nice.org.uk/guidance/ta165
31. Kay, M.D., *et al.* Comparison of preservation solutions in an experimental model of organ cooling in kidney transplantation. Br J Surg, 2009. 96: 1215.
https://pubmed.ncbi.nlm.nih.gov/19787767
32. Bond, M., *et al.* The effectiveness and cost-effectiveness of methods of storing donated kidneys from deceased donors: a systematic review and economic model. Health Technol Assess, 2009. 13: iii.
https://pubmed.ncbi.nlm.nih.gov/19674537
33. Lledo-Garcia, E., *et al.* Spanish consensus document for acceptance and rejection of kidneys from expanded criteria donors. Clin Transplant, 2014. 28: 1155.
https://pubmed.ncbi.nlm.nih.gov/25109314
34. Johnston, T.D., *et al.* Sensitivity of expanded-criteria donor kidneys to cold ischaemia time. Clin Transplant, 2004. 18 Suppl 12: 28.
https://pubmed.ncbi.nlm.nih.gov/15217404
35. Peters-Sengers, H., *et al.* Impact of Cold Ischemia Time on Outcomes of Deceased Donor Kidney Transplantation: An Analysis of a National Registry. Transplant Direct, 2019. 5: e448.
https://pubmed.ncbi.nlm.nih.gov/31165083
36. Summers, D.M., *et al.* Analysis of factors that affect outcome after transplantation of kidneys donated after cardiac death in the UK: a cohort study. Lancet, 2010. 376: 1303.
https://pubmed.ncbi.nlm.nih.gov/20727576

37. Aubert, O., *et al.* Long term outcomes of transplantation using kidneys from expanded criteria donors: prospective, population based cohort study. BMJ, 2015. 351: h3557.
https://pubmed.ncbi.nlm.nih.gov/26232393
38. Kayler, L.K., *et al.* Impact of cold ischemia time on graft survival among ECD transplant recipients: a paired kidney analysis. Am J Transplant, 2011. 11: 2647.
https://pubmed.ncbi.nlm.nih.gov/21906257
39. Chatauret, N., *et al.* Preservation strategies to reduce ischemic injury in kidney transplantation: pharmacological and genetic approaches. Curr Opin Organ Transplant, 2011. 16: 180.
https://pubmed.ncbi.nlm.nih.gov/21415820
40. Jochmans, I., *et al.* Past, Present, and Future of Dynamic Kidney and Liver Preservation and Resuscitation. Am J Transplant, 2016. 16: 2545.
https://pubmed.ncbi.nlm.nih.gov/26946212
41. O'Callaghan, J.M., *et al.* Systematic review and meta-analysis of hypothermic machine perfusion versus static cold storage of kidney allografts on transplant outcomes. Br J Surg, 2013. 100: 991.
https://pubmed.ncbi.nlm.nih.gov/23754643
42. Martinez Arcos, L., *et al.* Functional Results of Renal Preservation in Hypothermic Pulsatile Machine Perfusion Versus Cold Preservation: Systematic Review and Meta-Analysis of Clinical Trials. Transplant Proc, 2018. 50: 24.
https://pubmed.ncbi.nlm.nih.gov/29407316
43. Tingle, S.J., *et al.* Machine perfusion preservation versus static cold storage for deceased donor kidney transplantation. Cochrane Database Syst Rev, 2019. 3: CD011671.
https://pubmed.ncbi.nlm.nih.gov/30875082
44. Jochmans, I., *et al.* Machine perfusion versus cold storage for the preservation of kidneys donated after cardiac death: a multicenter, randomized, controlled trial. Ann Surg, 2010. 252: 756.
https://pubmed.ncbi.nlm.nih.gov/21037431
45. Reznik, O.N., *et al.* Machine perfusion as a tool to select kidneys recovered from uncontrolled donors after cardiac death. Transplant Proc, 2008. 40: 1023.
https://pubmed.ncbi.nlm.nih.gov/18555105
46. Jochmans, I., *et al.* Hypothermic machine perfusion of kidneys retrieved from standard and high-risk donors. Transpl Int, 2015. 28: 665.
https://pubmed.ncbi.nlm.nih.gov/25630347
47. Treckmann, J., *et al.* Machine perfusion versus cold storage for preservation of kidneys from expanded criteria donors after brain death. Transpl Int, 2011. 24: 548.
https://pubmed.ncbi.nlm.nih.gov/21332580
48. Gill, J., *et al.* Pulsatile perfusion reduces the risk of delayed graft function in deceased donor kidney transplants, irrespective of donor type and cold ischemic time. Transplantation, 2014. 97: 668.
https://pubmed.ncbi.nlm.nih.gov/24637865
49. Matsuno, N., *et al.* Machine perfusion preservation for kidney grafts with a high creatinine from uncontrolled donation after cardiac death. Transplant Proc, 2010. 42: 155.
https://pubmed.ncbi.nlm.nih.gov/20172304
50. Jochmans, I., *et al.* Graft quality assessment in kidney transplantation: not an exact science yet! Curr Opin Organ Transplant, 2011. 16: 174.
https://pubmed.ncbi.nlm.nih.gov/21383549
51. Jochmans, I., *et al.* Oxygenated Hypothermic Machine Perfusion of Kidneys Donated after Circulatory Death: An International Randomised Controlled Trial [abstract]. Am J Transplant, 2019. 19.
https://atcmeetingabstracts.com/abstract/oxygenated-hypothermic-machine-perfusion-of-kidneys-donated-after-circulatory-death-an-international-randomised-controlled-trial/
52. Hosgood, S.A., *et al.* Normothermic machine perfusion of the kidney: better conditioning and repair? Transpl Int, 2015. 28: 657.
https://pubmed.ncbi.nlm.nih.gov/24629095
53. Reddy, S.P., *et al.* Normothermic perfusion: a mini-review. Transplantation, 2009. 87: 631.
https://pubmed.ncbi.nlm.nih.gov/19295304
54. Antoine, C., *et al.* Kidney Transplant From Uncontrolled Donation After Circulatory Death: Contribution of Normothermic Regional Perfusion. Transplantation, 2020. 104: 130.
https://pubmed.ncbi.nlm.nih.gov/30985577
55. Reznik, O., *et al.* Kidney from uncontrolled donors after cardiac death with one hour warm ischemic time: resuscitation by extracorporal normothermic abdominal perfusion "*in situ*" by leukocytes-free oxygenated blood. Clin Transplant, 2011. 25: 511.
https://pubmed.ncbi.nlm.nih.gov/20973824

56. Hosgood, S.A., *et al.* Ex vivo normothermic perfusion for quality assessment of marginal donor kidney transplants. Br J Surg, 2015. 102: 1433.
https://pubmed.ncbi.nlm.nih.gov/26313559
57. Hoyer, D.P., *et al.* Subnormothermic machine perfusion for preservation of porcine kidneys in a donation after circulatory death model. Transpl Int, 2014. 27: 1097.
https://pubmed.ncbi.nlm.nih.gov/24963744
58. Naesens, M. Zero-Time Renal Transplant Biopsies: A Comprehensive Review. Transplantation, 2016. 100: 1425.
https://pubmed.ncbi.nlm.nih.gov/26599490
59. Reese, P.P., *et al.* Assessment of the Utility of Kidney Histology as a Basis for Discarding Organs in the United States: A Comparison of International Transplant Practices and Outcomes. J Am Soc Nephrol, 2021. 32: 397.
https://pubmed.ncbi.nlm.nih.gov/33323474
60. Kasiske, B.L., *et al.* The role of procurement biopsies in acceptance decisions for kidneys retrieved for transplant. Clin J Am Soc Nephrol, 2014. 9: 562.
https://pubmed.ncbi.nlm.nih.gov/24558053
61. Marrero, W.J., *et al.* Predictors of Deceased Donor Kidney Discard in the United States. Transplantation, 2016.
https://pubmed.ncbi.nlm.nih.gov/27163541
62. Sung, R.S., *et al.* Determinants of discard of expanded criteria donor kidneys: impact of biopsy and machine perfusion. Am J Transplant, 2008. 8: 783.
https://pubmed.ncbi.nlm.nih.gov/18294347
63. Lentine, K.L., *et al.* Deceased Donor Procurement Biopsy Practices, Interpretation, and Histology-Based Decision-Making: A Survey of US Kidney Transplant Centers. Kidney Int Rep, 2022. 7: 1268.
https://pubmed.ncbi.nlm.nih.gov/35685316
64. Wang, C.J., *et al.* The Donor Kidney Biopsy and Its Implications in Predicting Graft Outcomes: A Systematic Review. Am J Transplant, 2015. 15: 1903.
https://pubmed.ncbi.nlm.nih.gov/25772854
65. Hopfer, H., *et al.* Assessment of donor biopsies. Curr Opin Organ Transplant, 2013. 18: 306.
https://pubmed.ncbi.nlm.nih.gov/23492644
66. Gaber, L.W., *et al.* Glomerulosclerosis as a determinant of posttransplant function of older donor renal allografts. Transplantation, 1995. 60: 334.
https://pubmed.ncbi.nlm.nih.gov/7652761
67. Solez, K., *et al.* Banff 07 classification of renal allograft pathology: updates and future directions. Am J Transplant, 2008. 8: 753.
https://pubmed.ncbi.nlm.nih.gov/18294345
68. De Vusser, K., *et al.* The predictive value of kidney allograft baseline biopsies for long-term graft survival. J Am Soc Nephrol, 2013. 24: 1913.
https://pubmed.ncbi.nlm.nih.gov/23949799
69. Anglicheau, D., *et al.* A simple clinico-histopathological composite scoring system is highly predictive of graft outcomes in marginal donors. Am J Transplant, 2008. 8: 2325.
https://pubmed.ncbi.nlm.nih.gov/18785957
70. Balaz, P., *et al.* Identification of expanded-criteria donor kidney grafts at lower risk of delayed graft function. Transplantation, 2013. 96: 633.
https://pubmed.ncbi.nlm.nih.gov/23912171
71. Lopes, J.A., *et al.* Evaluation of pre-implantation kidney biopsies: comparison of Banff criteria to a morphometric approach. Kidney Int, 2005. 67: 1595.
https://pubmed.ncbi.nlm.nih.gov/15780116
72. Munivenkatappa, R.B., *et al.* The Maryland aggregate pathology index: a deceased donor kidney biopsy scoring system for predicting graft failure. Am J Transplant, 2008. 8: 2316.
https://pubmed.ncbi.nlm.nih.gov/18801024
73. Liapis, H., *et al.* Banff Histopathological Consensus Criteria for Preimplantation Kidney Biopsies. Am J Transplant, 2016.
https://pubmed.ncbi.nlm.nih.gov/27333454
74. Haas, M. Donor kidney biopsies: pathology matters, and so does the pathologist. Kidney Int, 2014. 85: 1016.
https://pubmed.ncbi.nlm.nih.gov/24786876

75. Girolami, I., *et al.* Pre-implantation kidney biopsy: value of the expertise in determining histological score and comparison with the whole organ on a series of discarded kidneys. J Nephrol, 2020. 33: 167.
https://pubmed.ncbi.nlm.nih.gov/31471818
76. Azancot, M.A., *et al.* The reproducibility and predictive value on outcome of renal biopsies from expanded criteria donors. Kidney Int, 2014. 85: 1161.
https://pubmed.ncbi.nlm.nih.gov/24284518
77. Peters, B., *et al.* Sixteen Gauge biopsy needles are better and safer than 18 Gauge in native and transplant kidney biopsies. Acta Radiol, 2017. 58: 240.
https://pubmed.ncbi.nlm.nih.gov/27055922
78. Haas, M., *et al.* Arteriosclerosis in kidneys from healthy live donors: comparison of wedge and needle core perioperative biopsies. Arch Pathol Lab Med, 2008. 132: 37.
https://pubmed.ncbi.nlm.nih.gov/18181671
79. Mazzucco, G., *et al.* The reliability of pre-transplant donor renal biopsies (PTDB) in predicting the kidney state. A comparative single-centre study on 154 untransplanted kidneys. Nephrol Dial Transplant, 2010. 25: 3401.
https://pubmed.ncbi.nlm.nih.gov/20356979
80. Wang, H.J., *et al.* On the influence of sample size on the prognostic accuracy and reproducibility of renal transplant biopsy. Nephrol Dial Transplant, 1998. 13: 165.
https://pubmed.ncbi.nlm.nih.gov/9481734
81. Yushkov, Y., *et al.* Optimized technique in needle biopsy protocol shown to be of greater sensitivity and accuracy compared to wedge biopsy. Transplant Proc, 2010. 42: 2493.
https://pubmed.ncbi.nlm.nih.gov/20832530
82. Muruve, N.A., *et al.* Are wedge biopsies of cadaveric kidneys obtained at procurement reliable? Transplantation, 2000. 69: 2384.
https://pubmed.ncbi.nlm.nih.gov/10868645
83. Randhawa, P. Role of donor kidney biopsies in renal transplantation. Transplantation, 2001. 71: 1361.
https://pubmed.ncbi.nlm.nih.gov/11391219
84. Bago-Horvath, Z., *et al.* The cutting (w)edge--comparative evaluation of renal baseline biopsies obtained by two different methods. Nephrol Dial Transplant, 2012. 27: 3241.
https://pubmed.ncbi.nlm.nih.gov/22492825
85. Jankovic, Z. Anaesthesia for living-donor renal transplant. Current Anaesthesia & Critical Care, 2008. 19: 175.
https://www.researchgate.net/publication/270283251_Jankovic_Z_Anaesthesia_for_living-donor_renal_transplant_Curr_Anaesth_Crit_Care_2008_19_3_175-80
86. Karmarkar, S., *et al.* Kidney Transplantation. Anaesthesia And Intensive Care Medicine 2009. 10.5.
https://www.anaesthesiajournal.co.uk/article/S1472-0299(12)00070-7/abstract
87. Abramowicz, D., *et al.* European Renal Best Practice Guideline on kidney donor and recipient evaluation and perioperative care. Nephrol Dial Transplant, 2015. 30: 1790.
https://pubmed.ncbi.nlm.nih.gov/25007790
88. Van Loo, A.A., *et al.* Pretransplantation hemodialysis strategy influences early renal graft function. J Am Soc Nephrol, 1998. 9: 473.
https://pubmed.ncbi.nlm.nih.gov/9513911
89. Task Force for Preoperative Cardiac Risk, A., *et al.* Guidelines for pre-operative cardiac risk assessment and perioperative cardiac management in non-cardiac surgery. Eur Heart J, 2009. 30: 2769.
https://pubmed.ncbi.nlm.nih.gov/19713421
90. Douketis, J.D., *et al.* Perioperative management of antithrombotic therapy: Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. Chest, 2012. 141: e326S.
https://pubmed.ncbi.nlm.nih.gov/22315266
91. Benahmed, A., *et al.* Ticlopidine and clopidogrel, sometimes combined with aspirin, only minimally increase the surgical risk in renal transplantation: a case-control study. Nephrol Dial Transplant, 2014. 29: 463.
https://pubmed.ncbi.nlm.nih.gov/24275542
92. Osman, Y., *et al.* Necessity of routine postoperative heparinization in non-risky live-donor renal transplantation: results of a prospective randomized trial. Urology, 2007. 69: 647.
https://pubmed.ncbi.nlm.nih.gov/17445644

93. Orlando, G., *et al.* One-shot versus multidose perioperative antibiotic prophylaxis after kidney transplantation: a randomized, controlled clinical trial. Surgery, 2015. 157: 104.
https://pubmed.ncbi.nlm.nih.gov/25304836
94. Choi, S.U., *et al.* Clinical significance of prophylactic antibiotics in renal transplantation. Transplant Proc, 2013. 45: 1392.
https://pubmed.ncbi.nlm.nih.gov/23726580
95. O'Malley, C.M., *et al.* A randomized, double-blind comparison of lactated Ringer's solution and 0.9% NaCl during renal transplantation. Anesth Analg, 2005. 100: 1518.
https://pubmed.ncbi.nlm.nih.gov/15845718
96. Othman, M.M., *et al.* The impact of timing of maximal crystalloid hydration on early graft function during kidney transplantation. Anesth Analg, 2010. 110: 1440.
https://pubmed.ncbi.nlm.nih.gov/20418304
97. Dalton, R.S., *et al.* Physiologic impact of low-dose dopamine on renal function in the early post renal transplant period. Transplantation, 2005. 79: 1561.
https://pubmed.ncbi.nlm.nih.gov/15940046
98. Ciapetti, M., *et al.* Low-dose dopamine in kidney transplantation. Transplant Proc, 2009. 41: 4165.
https://pubmed.ncbi.nlm.nih.gov/20005360
99. Hanif, F., *et al.* Outcome of renal transplantation with and without intra-operative diuretics. Int J Surg, 2011. 9: 460.
https://pubmed.ncbi.nlm.nih.gov/21600319
100. Valeriani, G., *et al.* Bench surgery in right kidney transplantation. Transplant Proc, 2010. 42: 1120.
https://pubmed.ncbi.nlm.nih.gov/20534239
101. Wagenaar, S., *et al.* Minimally Invasive, Laparoscopic, and Robotic-assisted Techniques Versus Open Techniques for Kidney Transplant Recipients: A Systematic Review. Eur Urol, 2017. 72: 205.
https://pubmed.ncbi.nlm.nih.gov/28262412
102. Chedid, M.F., *et al.* Living donor kidney transplantation using laparoscopically procured multiple renal artery kidneys and right kidneys. J Am Coll Surg, 2013. 217: 144.
https://pubmed.ncbi.nlm.nih.gov/23791283
103. Kaminska, D., *et al.* The influence of warm ischemia elimination on kidney injury during transplantation - clinical and molecular study. Sci Rep, 2016. 6: 36118.
https://pubmed.ncbi.nlm.nih.gov/27808277
104. Ozdemir-van Brunschot, D.M., *et al.* Is the Reluctance for the Implantation of Right Donor Kidneys Justified? World J Surg, 2016. 40: 471.
https://pubmed.ncbi.nlm.nih.gov/26319261
105. Khalil, A., *et al.* Trends and outcomes in right vs. left living donor nephrectomy: an analysis of the OPTN/UNOS database of donor and recipient outcomes--should we be doing more right-sided nephrectomies? Clin Transplant, 2016. 30: 145.
https://pubmed.ncbi.nlm.nih.gov/26589133
106. Hsu, J.W., *et al.* Increased early graft failure in right-sided living donor nephrectomy. Transplantation, 2011. 91: 108.
https://pubmed.ncbi.nlm.nih.gov/21441855
107. Kulkarni, S., *et al.* Outcomes From Right Versus Left Deceased-Donor Kidney Transplants: A US National Cohort Study. Am J Kidney Dis, 2020. 75: 725.
https://pubmed.ncbi.nlm.nih.gov/31812448
108. Wang, K., *et al.* Right Versus Left Laparoscopic Living-Donor Nephrectomy: A Meta-Analysis. Exp Clin Transplant, 2015. 13: 214.
https://pubmed.ncbi.nlm.nih.gov/26086831
109. Ciudin, A., *et al.* Transposition of iliac vessels in implantation of right living donor kidneys. Transplant Proc, 2012. 44: 2945.
https://pubmed.ncbi.nlm.nih.gov/23195003
110. Phelan, P.J., *et al.* Left versus right deceased donor renal allograft outcome. Transpl Int, 2009. 22: 1159.
https://pubmed.ncbi.nlm.nih.gov/19891044
111. Feng, J.Y., *et al.* Renal vein lengthening using gonadal vein reduces surgical difficulty in living-donor kidney transplantation. World J Surg, 2012. 36: 468.
https://pubmed.ncbi.nlm.nih.gov/21882021
112. Nghiem, D.D. Use of spiral vein graft in living donor renal transplantation. Clin Transplant, 2008. 22: 719.
https://pubmed.ncbi.nlm.nih.gov/18673376

113. Matheus, W.E., *et al.* Kidney transplant anastomosis: internal or external iliac artery? Urol J, 2009. 6: 260.
https://pubmed.ncbi.nlm.nih.gov/20027554
114. El-Sherbiny, M., *et al.* The use of the inferior epigastric artery for accessory lower polar artery revascularization in live donor renal transplantation. Int Urol Nephrol, 2008. 40: 283.
https://pubmed.ncbi.nlm.nih.gov/17721826
115. Firmin, L.C., *et al.* The use of explanted internal iliac artery grafts in renal transplants with multiple arteries. Transplantation, 2010. 89: 766.
https://pubmed.ncbi.nlm.nih.gov/20308866
116. Oertl, A.J., *et al.* Saphenous vein interposition as a salvage technique for complex vascular situations during renal transplantation. Transplant Proc, 2007. 39: 140.
https://pubmed.ncbi.nlm.nih.gov/17275492
117. Tozzi, M., *et al.* Treatment of aortoiliac occlusive or dilatative disease concomitant with kidney transplantation: how and when? Int J Surg, 2013. 11 Suppl 1: S115.
https://pubmed.ncbi.nlm.nih.gov/24380542
118. Franchin, M., *et al.* ePTFE suture is an effective tool for vascular anastomosis in kidney transplantation. Italian Journal of Vascular and Endovascular Surgery, 2015. 22: 61.
https://www.researchgate.net/publication/285219004_ePTFE_suture_is_an_effective_tool_for_vascular_anastomosis_in_kidney_tra
119. Izquierdo, L., *et al.* Third and fourth kidney transplant: still a reasonable option. Transplant Proc, 2010. 42: 2498.
https://pubmed.ncbi.nlm.nih.gov/20832531
120. Blanco, M., *et al.* Third kidney transplantation: a permanent medical-surgical challenge. Transplant Proc, 2009. 41: 2366.
https://pubmed.ncbi.nlm.nih.gov/19715921
121. Nourbala, M.H., *et al.* Our experience with third renal transplantation: results, surgical techniques and complications. Int J Urol, 2007. 14: 1057.
https://pubmed.ncbi.nlm.nih.gov/18036037
122. Musquera, M., *et al.* Orthotopic kidney transplantation: an alternative surgical technique in selected patients. Eur Urol, 2010. 58: 927.
https://pubmed.ncbi.nlm.nih.gov/20888120
123. Heylen, L., *et al.* The Impact of Anastomosis Time During Kidney Transplantation on Graft Loss: A Eurotransplant Cohort Study. Am J Transplant, 2017. 17: 724.
https://pubmed.ncbi.nlm.nih.gov/27593738
124. Weissenbacher, A., *et al.* The faster the better: anastomosis time influences patient survival after deceased donor kidney transplantation. Transpl Int, 2015. 28: 535.
https://pubmed.ncbi.nlm.nih.gov/25557890
125. McCulloch, P., *et al.* IDEAL framework for surgical innovation 1: the idea and development stages. BMJ, 2013. 346: f3012.
https://pubmed.ncbi.nlm.nih.gov/23778427
126. Breda, A., *et al.* Robot-assisted Kidney Transplantation: The European Experience. Eur Urol, 2018. 73: 273.
https://pubmed.ncbi.nlm.nih.gov/28916408
127. Gallioli, A., *et al.* Learning Curve in Robot-assisted Kidney Transplantation: Results from the European Robotic Urological Society Working Group. Eur Urol, 2020. 78: 239.
https://pubmed.ncbi.nlm.nih.gov/31928760
128. Tzvetanov, I.G., *et al.* Robotic kidney transplantation in the obese patient: 10-year experience from a single center. Am J Transplant, 2020. 20: 430.
https://pubmed.ncbi.nlm.nih.gov/31571369
129. Basu, A., *et al.* Adult dual kidney transplantation. Current Opinion in Organ Transplantation, 2007. 12: 379.
https://journals.lww.com/co-transplantation/Abstract/2007/08000/Adult_dual_kidney_transplantation.10.aspx
130. Haider, H.H., *et al.* Dual kidney transplantation using midline extraperitoneal approach: description of a technique. Transplant Proc, 2007. 39: 1118.
https://pubmed.ncbi.nlm.nih.gov/17524907
131. Ekser, B., *et al.* Technical aspects of unilateral dual kidney transplantation from expanded criteria donors: experience of 100 patients. Am J Transplant, 2010. 10: 2000.
https://pubmed.ncbi.nlm.nih.gov/20636454

132. Nghiem, D.D. Simultaneous double adult kidney transplantation using single arterial and venous anastomoses. Urology, 2006. 67: 1076.
https://pubmed.ncbi.nlm.nih.gov/16581114
133. Veroux, P., *et al.* Two-as-one monolateral dual kidney transplantation. Urology, 2011. 77: 227.
https://pubmed.ncbi.nlm.nih.gov/20399490
134. Salehipour, M., *et al. En-bloc* Transplantation: an Eligible Technique for Unilateral Dual Kidney Transplantation. Int J Organ Transplant Med, 2012. 3: 111.
https://pubmed.ncbi.nlm.nih.gov/25013633
135. Rigotti, P., *et al.* A single-center experience with 200 dual kidney transplantations. Clin Transplant, 2014. 28: 1433.
https://pubmed.ncbi.nlm.nih.gov/25297945
136. Al-Shraideh, Y., *et al.* Single vs dual (*en bloc*) kidney transplants from donors </= 5 years of age: A single center experience. World J Transplant, 2016. 6: 239.
https://pubmed.ncbi.nlm.nih.gov/27011923
137. Alberts, V.P., *et al.* Ureterovesical anastomotic techniques for kidney transplantation: a systematic review and meta-analysis. Transpl Int, 2014. 27: 593.
https://pubmed.ncbi.nlm.nih.gov/24606191
138. Slagt, I.K., *et al.* A randomized controlled trial comparing intravesical to extravesical ureteroneocystostomy in living donor kidney transplantation recipients. Kidney Int, 2014. 85: 471.
https://pubmed.ncbi.nlm.nih.gov/24284515
139. Timsit, M.O., *et al.* Should routine pyeloureterostomy be advocated in adult kidney transplantation? A prospective study of 283 recipients. J Urol, 2010. 184: 2043.
https://pubmed.ncbi.nlm.nih.gov/20850818
140. Suttle, T., *et al.* Comparison of urologic complications between ureteroneocystostomy and ureteroureterostomy in renal transplant: A meta-analysis. Experimental and Clinical Transplantation, 2016. 14: 276.
https://pubmed.ncbi.nlm.nih.gov/610598765
141. Dadkhah, F., *et al.* Modified ureteroneocystostomy in kidney transplantation to facilitate endoscopic management of subsequent urological complications. Int Urol Nephrol, 2010. 42: 285.
https://pubmed.ncbi.nlm.nih.gov/19760513
142. Kehinde, E.O., *et al.* Complications associated with using nonabsorbable sutures for ureteroneocystostomy in renal transplant operations. Transplant Proc, 2000. 32: 1917.
https://pubmed.ncbi.nlm.nih.gov/11119999
143. Wilson, C.H., *et al.* Routine intraoperative ureteric stenting for kidney transplant recipients. Cochrane Database Syst Rev, 2013: CD004925.
https://pubmed.ncbi.nlm.nih.gov/23771708
144. Tavakoli, A., *et al.* Impact of stents on urological complications and health care expenditure in renal transplant recipients: results of a prospective, randomized clinical trial. J Urol, 2007. 177: 2260.
https://pubmed.ncbi.nlm.nih.gov/17509336
145. Cai, J.F., *et al.* Meta-analysis of Early Versus Late Ureteric Stent Removal After Kidney Transplantation. Transplant Proc, 2018. 50: 3411.
https://pubmed.ncbi.nlm.nih.gov/30577214
146. Visser, I.J., *et al.* Timing of Ureteric Stent Removal and Occurrence of Urological Complications after Kidney Transplantation: A Systematic Review and Meta-Analysis. J Clin Med, 2019. 8.
https://pubmed.ncbi.nlm.nih.gov/31100847
147. Patel, P., *et al.* Prophylactic Ureteric Stents in Renal Transplant Recipients: A Multicenter Randomized Controlled Trial of Early Versus Late Removal. Am J Transplant, 2017. 17: 2129.
https://pubmed.ncbi.nlm.nih.gov/28188678
148. Heidari, M., *et al.* Transplantation of kidneys with duplicated ureters. Scand J Urol Nephrol, 2010. 44: 337.
https://pubmed.ncbi.nlm.nih.gov/20653492
149. Alberts, V.P., *et al.* Duplicated ureters and renal transplantation: a case-control study and review of the literature. Transplant Proc, 2013. 45: 3239.
https://pubmed.ncbi.nlm.nih.gov/24182792
150. Surange, R.S., *et al.* Kidney transplantation into an ileal conduit: a single center experience of 59 cases. J Urol, 2003. 170: 1727.
https://pubmed.ncbi.nlm.nih.gov/14532763
151. Kortram, K., *et al.* Perioperative Events and Complications in Minimally Invasive Live Donor Nephrectomy: A Systematic Review and Meta-Analysis. Transplantation, 2016.
https://pubmed.ncbi.nlm.nih.gov/27428715

152. Segev, D.L., *et al.* Perioperative mortality and long-term survival following live kidney donation. JAMA, 2010. 303: 959.
https://pubmed.ncbi.nlm.nih.gov/20215610
153. Chu, K.H., *et al.* Long-term outcomes of living kidney donors: a single centre experience of 29 years. Nephrology (Carlton), 2012. 17: 85.
https://pubmed.ncbi.nlm.nih.gov/21919999
154. Fehrman-Ekholm, I., *et al.* Post-nephrectomy development of renal function in living kidney donors: a cross-sectional retrospective study. Nephrol Dial Transplant, 2011. 26: 2377.
https://pubmed.ncbi.nlm.nih.gov/21459783
155. Li, S.S., *et al.* A meta-analysis of renal outcomes in living kidney donors. [Review]. Medicine, 2016. 95.
https://pubmed.ncbi.nlm.nih.gov/27310964
156. Thiel, G.T., *et al.* Investigating kidney donation as a risk factor for hypertension and microalbuminuria: findings from the Swiss prospective follow-up of living kidney donors. BMJ Open, 2016. 6: 22.
https://pubmed.ncbi.nlm.nih.gov/27006347
157. Bellini, M.I., *et al.* Risks for donors associated with living kidney donation: meta-analysis. Br J Surg, 2022. 109: 671.
https://pubmed.ncbi.nlm.nih.gov/35612960
158. Haugen, A.J., *et al.* Increased risk of ischaemic heart disease after kidney donation. Nephrol Dial Transplant, 2022. 37: 928.
https://pubmed.ncbi.nlm.nih.gov/33624826
159. Ibrahim, H.N., *et al.* Long-term consequences of kidney donation. N Engl J Med, 2009. 360: 459.
https://pubmed.ncbi.nlm.nih.gov/19179315
160. Li, S.S., *et al.* A meta-analysis of renal outcomes in living kidney donors. Medicine (Baltimore), 2016. 95: e3847.
https://pubmed.ncbi.nlm.nih.gov/27310964
161. Matas, A.J., *et al.* Causes and timing of end-stage renal disease after living kidney donation. Am J Transplant, 2018. 18: 1140.
https://pubmed.ncbi.nlm.nih.gov/29369517
162. Locke, J.E., *et al.* Obesity increases the risk of end-stage renal disease among living kidney donors. Kidney Int, 2017. 91: 699.
https://pubmed.ncbi.nlm.nih.gov/28041626
163. Gross, C.R., *et al.* Health-related quality of life in kidney donors from the last five decades: results from the RELIVE study. Am J Transplant, 2013. 13: 2924.
https://pubmed.ncbi.nlm.nih.gov/24011252
164. Maggiore, U., *et al.* Long-term risks of kidney living donation: Review and position paper by the ERA-EDTA DESCARTES working group. Nephrology Dialysis Transplantation, 2017. 32: 216.
https://pubmed.ncbi.nlm.nih.gov/614992517
165. Lorenz, E.C., *et al.* The impact of urinary tract infections in renal transplant recipients. Kidney Int, 2010. 78: 719.
https://pubmed.ncbi.nlm.nih.gov/20877371
166. Ariza-Heredia, E.J., *et al.* Urinary tract infections in kidney transplant recipients: role of gender, urologic abnormalities, and antimicrobial prophylaxis. Ann Transplant, 2013. 18: 195.
https://pubmed.ncbi.nlm.nih.gov/23792521
167. Chang, C.Y., *et al.* Urological manifestations of BK polyomavirus in renal transplant recipients. Can J Urol, 2005. 12: 2829.
https://pubmed.ncbi.nlm.nih.gov/16274519
168. Hwang, J.K., *et al.* Comparative analysis of ABO-incompatible living donor kidney transplantation with ABO-compatible grafts: a single-center experience in Korea. Transplant Proc, 2013. 45: 2931.
https://pubmed.ncbi.nlm.nih.gov/24157006
169. Habicht, A., *et al.* Increase of infectious complications in ABO-incompatible kidney transplant recipients--a single centre experience. Nephrol Dial Transplant, 2011. 26: 4124.
https://pubmed.ncbi.nlm.nih.gov/21622990
170. Sorto, R., *et al.* Risk factors for urinary tract infections during the first year after kidney transplantation. Transplant Proc, 2010. 42: 280.
https://pubmed.ncbi.nlm.nih.gov/20172330
171. Thrasher, J.B., *et al.* Extravesical versus Leadbetter-Politano ureteroneocystostomy: a comparison of urological complications in 320 renal transplants. J Urol, 1990. 144: 1105.
https://pubmed.ncbi.nlm.nih.gov/2231880

172. Mangus, R.S., *et al.* Stented versus nonstented extravesical ureteroneocystostomy in renal transplantation: a metaanalysis. Am J Transplant, 2004. 4: 1889.
https://pubmed.ncbi.nlm.nih.gov/15476491
173. Wilson, C.H., *et al.* Routine intraoperative ureteric stenting for kidney transplant recipients. Cochrane Database Syst Rev, 2005: CD004925.
https://pubmed.ncbi.nlm.nih.gov/16235385
174. Osman, Y., *et al.* Routine insertion of ureteral stent in live-donor renal transplantation: is it worthwhile? Urology, 2005. 65: 867.
https://pubmed.ncbi.nlm.nih.gov/15882713
175. Georgiev, P., *et al.* Routine stenting reduces urologic complications as compared with stenting "on demand" in adult kidney transplantation. Urology, 2007. 70: 893.
https://pubmed.ncbi.nlm.nih.gov/17919691
176. Akoh, J.A., *et al.* Effect of ureteric stents on urological infection and graft function following renal transplantation. World J Transplant, 2013. 3: 1.
https://pubmed.ncbi.nlm.nih.gov/24175202
177. Fayek, S.A., *et al.* Ureteral stents are associated with reduced risk of ureteral complications after kidney transplantation: a large single center experience. Transplantation, 2012. 93: 304.
https://pubmed.ncbi.nlm.nih.gov/22179401
178. Dimitroulis, D., *et al.* Vascular complications in renal transplantation: a single-center experience in 1367 renal transplantations and review of the literature. Transplant Proc, 2009. 41: 1609.
https://pubmed.ncbi.nlm.nih.gov/19545690
179. Pawlicki, J., *et al.* Risk factors for early hemorrhagic and thrombotic complications after kidney transplantation. Transplant Proc, 2011. 43: 3013.
https://pubmed.ncbi.nlm.nih.gov/21996213
180. Rouviere, O., *et al.* Acute thrombosis of renal transplant artery: graft salvage by means of intra-arterial fibrinolysis. Transplantation, 2002. 73: 403.
https://pubmed.ncbi.nlm.nih.gov/11884937
181. Domagala, P., *et al.* Complications of transplantation of kidneys from expanded-criteria donors. Transplant Proc, 2009. 41: 2970.
https://pubmed.ncbi.nlm.nih.gov/19857652
182. Ammi, M., *et al.* Evaluation of the Vascular Surgical Complications of Renal Transplantation. Annals of Vascular Surgery, 2016. 33: 23.
https://pubmed.ncbi.nlm.nih.gov/614681588
183. Giustacchini, P., *et al.* Renal vein thrombosis after renal transplantation: an important cause of graft loss. Transplant Proc, 2002. 34: 2126.
https://pubmed.ncbi.nlm.nih.gov/12270338
184. Wuthrich, R.P. Factor V Leiden mutation: potential thrombogenic role in renal vein, dialysis graft and transplant vascular thrombosis. Curr Opin Nephrol Hypertens, 2001. 10: 409.
https://pubmed.ncbi.nlm.nih.gov/11342806
185. Parajuli, S., *et al.* Hypercoagulability in Kidney Transplant Recipients. Transplantation, 2016. 100: 719.
https://pubmed.ncbi.nlm.nih.gov/26413991
186. Granata, A., *et al.* Renal transplant vascular complications: the role of Doppler ultrasound. J Ultrasound, 2015. 18: 101.
https://pubmed.ncbi.nlm.nih.gov/26191097
187. Hogan, J.L., *et al.* Late-onset renal vein thrombosis: A case report and review of the literature. Int J Surg Case Rep, 2015. 6C: 73.
https://pubmed.ncbi.nlm.nih.gov/25528029
188. Musso, D., *et al.* Symptomatic Venous Thromboembolism and Major Bleeding After Renal Transplantation: Should We Use Pharmacologic Thromboprophylaxis? Transplantation Proceedings, 2016. 48: 2773.
https://pubmed.ncbi.nlm.nih.gov/613014201
189. Hurst, F.P., *et al.* Incidence, predictors and outcomes of transplant renal artery stenosis after kidney transplantation: analysis of USRDS. Am J Nephrol, 2009. 30: 459.
https://pubmed.ncbi.nlm.nih.gov/19776559
190. Willicombe, M., *et al.* Postanastomotic transplant renal artery stenosis: association with *de novo* class II donor-specific antibodies. Am J Transplant, 2014. 14: 133.
https://pubmed.ncbi.nlm.nih.gov/24354873
191. Ghazanfar, A., *et al.* Management of transplant renal artery stenosis and its impact on long-term allograft survival: a single-centre experience. Nephrol Dial Transplant, 2011. 26: 336.
https://pubmed.ncbi.nlm.nih.gov/20601365

192. Seratnahaei, A., *et al.* Management of transplant renal artery stenosis. Angiology, 2011. 62: 219.
https://pubmed.ncbi.nlm.nih.gov/20682611
193. Rountas, C., *et al.* Imaging modalities for renal artery stenosis in suspected renovascular hypertension: prospective intraindividual comparison of color Doppler US, CT angiography, GD-enhanced MR angiography, and digital substraction angiography. Ren Fail, 2007. 29: 295.
https://pubmed.ncbi.nlm.nih.gov/17497443
194. Fervenza, F.C., *et al.* Renal artery stenosis in kidney transplants. Am J Kidney Dis, 1998. 31: 142.
https://pubmed.ncbi.nlm.nih.gov/9428466
195. Bach, D., *et al.* Percutaneous renal biopsy: three years of experience with the biopty gun in 761 cases--a survey of results and complications. Int Urol Nephrol, 1999. 31: 15.
https://pubmed.ncbi.nlm.nih.gov/10408297
196. Loffroy, R., *et al.* Management of post-biopsy renal allograft arteriovenous fistulas with selective arterial embolization: immediate and long-term outcomes. Clin Radiol, 2008. 63: 657.
https://pubmed.ncbi.nlm.nih.gov/18455557
197. Atray, N.K., *et al.* Post transplant lymphocele: a single centre experience. Clin Transplant, 2004. 18 Suppl 12: 46.
https://pubmed.ncbi.nlm.nih.gov/15217407
198. Ulrich, F., *et al.* Symptomatic lymphoceles after kidney transplantation - multivariate analysis of risk factors and outcome after laparoscopic fenestration. Clin Transplant, 2010. 24: 273.
https://pubmed.ncbi.nlm.nih.gov/19719727
199. Lucewicz, A., *et al.* Management of primary symptomatic lymphocele after kidney transplantation: a systematic review. Transplantation, 2011. 92: 663.
https://pubmed.ncbi.nlm.nih.gov/21849931
200. Capocasale, E., *et al.* Octreotide in the treatment of lymphorrhea after renal transplantation: a preliminary experience. Transplant Proc, 2006. 38: 1047.
https://pubmed.ncbi.nlm.nih.gov/16757259
201. Kayler, L., *et al.* Kidney transplant ureteroneocystostomy techniques and complications: review of the literature. Transplant Proc, 2010. 42: 1413.
https://pubmed.ncbi.nlm.nih.gov/20620446
202. Secin, F.P., *et al.* Comparing Taguchi and Lich-Gregoir ureterovesical reimplantation techniques for kidney transplants. J Urol, 2002. 168: 926.
https://pubmed.ncbi.nlm.nih.gov/12187192
203. Dinckan, A., *et al.* Early and late urological complications corrected surgically following renal transplantation. Transpl Int, 2007. 20: 702.
https://pubmed.ncbi.nlm.nih.gov/17511829
204. Kumar, A., *et al.* Evaluation of the urological complications of living related renal transplantation at a single center during the last 10 years: impact of the Double-J* stent. J Urol, 2000. 164: 657.
https://pubmed.ncbi.nlm.nih.gov/10953120
205. Mazzucchi, E., *et al.* Primary reconstruction is a good option in the treatment of urinary fistula after kidney transplantation. Int Braz J Urol, 2006. 32: 398.
https://pubmed.ncbi.nlm.nih.gov/16953905
206. Davari, H.R., *et al.* Urological complications in 980 consecutive patients with renal transplantation. Int J Urol, 2006. 13: 1271.
https://pubmed.ncbi.nlm.nih.gov/17010003
207. Sabnis, R.B., *et al.* The development and current status of minimally invasive surgery to manage urological complications after renal transplantation. Indian J Urol, 2016. 32: 186.
https://pubmed.ncbi.nlm.nih.gov/27555675
208. Breda, A., *et al.* Incidence of ureteral strictures after laparoscopic donor nephrectomy. J Urol, 2006. 176: 1065.
https://pubmed.ncbi.nlm.nih.gov/16890691
209. Helfand, B.T., *et al.* Reconstruction of late-onset transplant ureteral stricture disease. BJU Int, 2011. 107: 982.
https://pubmed.ncbi.nlm.nih.gov/20825404
210. Kaskarelis, I., *et al.* Ureteral complications in renal transplant recipients successfully treated with interventional radiology. Transplant Proc, 2008. 40: 3170.
https://pubmed.ncbi.nlm.nih.gov/19010224
211. Gabr, A.H., *et al.* Ureteral complications after hand-assisted laparoscopic living donor nephrectomy. Transplantation, 2014. 97: 788.
https://pubmed.ncbi.nlm.nih.gov/24305639

212. Kristo, B., *et al.* Treatment of renal transplant ureterovesical anastomotic strictures using antegrade balloon dilation with or without holmium:YAG laser endoureterotomy. Urology, 2003. 62: 831.
https://pubmed.ncbi.nlm.nih.gov/14624903
213. Nie, Z., *et al.* Comparison of urological complications with primary ureteroureterostomy versus conventional ureteroneocystostomy. Clin Transplant, 2010. 24: 615.
https://pubmed.ncbi.nlm.nih.gov/19925475
214. Chaykovska, L., *et al.* Kidney transplantation into urinary conduits with ureteroureterostomy between transplant and native ureter: single-center experience. Urology, 2009. 73: 380.
https://pubmed.ncbi.nlm.nih.gov/19022489
215. Kumar, S., *et al.* Long-term graft and patient survival after balloon dilation of ureteric stenosis after renal transplant: A 23-year retrospective matched cohort study. Radiology, 2016. 281: 301.
https://pubmed.ncbi.nlm.nih.gov/612480205
216. Jung, G.O., *et al.* Clinical significance of posttransplantation vesicoureteral reflux during short-term period after kidney transplantation. Transplant Proc, 2008. 40: 2339.
https://pubmed.ncbi.nlm.nih.gov/18790229
217. Giral, M., *et al.* Acute graft pyelonephritis and long-term kidney allograft outcome. Kidney Int, 2002. 61: 1880.
https://pubmed.ncbi.nlm.nih.gov/11967040
218. Pichler, R., *et al.* Endoscopic application of dextranomer/hyaluronic acid copolymer in the treatment of vesico-ureteric reflux after renal transplantation. BJU Int, 2011. 107: 1967.
https://pubmed.ncbi.nlm.nih.gov/21059169
219. Abbott, K.C., *et al.* Hospitalized nephrolithiasis after renal transplantation in the United States. Am J Transplant, 2003. 3: 465.
https://pubmed.ncbi.nlm.nih.gov/12694070
220. Verrier, C., *et al.* Decrease in and management of urolithiasis after kidney transplantation. J Urol, 2012. 187: 1651.
https://pubmed.ncbi.nlm.nih.gov/22425102
221. Oliveira, M., *et al.* Percutaneous nephrolithotomy in renal transplants: a safe approach with a high stone-free rate. Int Urol Nephrol, 2011. 43: 329.
https://pubmed.ncbi.nlm.nih.gov/20848196
222. Silva, A., *et al.* Risk factors for urinary tract infection after renal transplantation and its impact on graft function in children and young adults. J Urol, 2010. 184: 1462.
https://pubmed.ncbi.nlm.nih.gov/20727542
223. Challacombe, B., *et al.* Multimodal management of urolithiasis in renal transplantation. BJU Int, 2005. 96: 385.
https://pubmed.ncbi.nlm.nih.gov/16042735
224. Basiri, A., *et al.* Ureteroscopic management of urological complications after renal transplantation. Scand J Urol Nephrol, 2006. 40: 53.
https://pubmed.ncbi.nlm.nih.gov/16452057
225. Roine, E., *et al.* Targeting risk factors for impaired wound healing and wound complications after kidney transplantation. Transplant Proc, 2010. 42: 2542.
https://pubmed.ncbi.nlm.nih.gov/20832540
226. Yannam, G.R., *et al.* Experience of laparoscopic incisional hernia repair in kidney and/or pancreas transplant recipients. Am J Transplant, 2011. 11: 279.
https://pubmed.ncbi.nlm.nih.gov/21272235
227. Boissier, R., *et al.* The Risk of Tumour Recurrence in Patients Undergoing Renal Transplantation for End-stage Renal Disease after Previous Treatment for a Urological Cancer: A Systematic Review. Eur Urol, 2018. 73: 94.
https://pubmed.ncbi.nlm.nih.gov/28803033
228. Hevia, V., *et al.* Effectiveness and Harms of Using Kidneys with Small Renal Tumors from Deceased or Living Donors as a Source of Renal Transplantation: A Systematic Review. Eur Urol Focus, 2018.
https://pubmed.ncbi.nlm.nih.gov/29433988
229. Hevia, V., *et al.* Management of Localised Prostate Cancer in Kidney Transplant Patients: A Systematic Review from the EAU Guidelines on Renal Transplantation Panel. Eur Urol Focus, 2018. 4: 153.
https://pubmed.ncbi.nlm.nih.gov/29921544
230. Marra, G., *et al.* Prostate cancer treatment in renal transplant recipients: a systematic review. BJU Int, 2018. 121: 327.
https://pubmed.ncbi.nlm.nih.gov/28921938

231. Tait, B.D., *et al.* Consensus guidelines on the testing and clinical management issues associated with HLA and non-HLA antibodies in transplantation. Transplantation, 2013. 95: 19.
https://pubmed.ncbi.nlm.nih.gov/23238534
232. European Renal Best Practice Transplantation Guideline Development Group. ERBP Guideline on the Management and Evaluation of the Kidney Donor and Recipient. Nephrol Dial Transplant, 2013. 28 Suppl 2: ii1.
https://pubmed.ncbi.nlm.nih.gov/24026881
233. Poulton, K., *et al.* British Transplantation Society. Guidelines for the detection of clinically relevant antibodies in allotransplantation. 2014.
https://bts.org.uk/wp-content/uploads/2016/09/06_BTS_BSHI_Antibodies-1.pdf
234. UNOS. Unitied Network For Organ Sharing Website: https://www.unos.org/
235. Heidt, S., Eurotransplant Manual version 3.1 Chapter 10 Histocompatibility. 2015.
236. European Federation for Immunogenetics, EFI Standards for Histocompatibility and Immunogenetics Testing Version 6.3. 2015.
237. De Meester, J., *et al.* Renal transplantation of highly sensitised patients via prioritised renal allocation programs. Shorter waiting time and above-average graft survival. Nephron, 2002. 92: 111.
https://pubmed.ncbi.nlm.nih.gov/12187093
238. Susal, C., *et al.* Algorithms for the determination of unacceptable HLA antigen mismatches in kidney transplant recipients. Tissue Antigens, 2013. 82: 83.
https://pubmed.ncbi.nlm.nih.gov/23718733
239. Bohmig, G.A., *et al.* Strategies to overcome the ABO barrier in kidney transplantation. Nat Rev Nephrol, 2015. 11: 732.
https://pubmed.ncbi.nlm.nih.gov/26324199
240. Zschiedrich, S., *et al.* An update on ABO-incompatible kidney transplantation. Transpl Int, 2015. 28: 387.
https://pubmed.ncbi.nlm.nih.gov/25387763
241. Higgins, R.M., *et al.* Antibody-incompatible kidney transplantation in 2015 and beyond. Nephrol Dial Transplant, 2015. 30: 1972.
https://pubmed.ncbi.nlm.nih.gov/25500804
242. Wongsaroj, P., *et al.* Modern approaches to incompatible kidney transplantation. World J Nephrol, 2015. 4: 354.
https://pubmed.ncbi.nlm.nih.gov/26167458
243. Bamoulid, J., *et al.* Immunosuppression and Results in Renal Transplantation. European Urology Supplements, 2016. 15: 415.
https://www.eu-openscience.europeanurology.com/article/S1569-9056(16)30082-3/fulltext
244. Kidney Disease Improving Global Outcomes Transplant Work Group. KDIGO clinical practice guideline for the care of kidney transplant recipients. Am J Transplant, 2009. 9 Suppl 3: S1.
https://pubmed.ncbi.nlm.nih.gov/19845597
245. Bamoulid, J., *et al.* The need for minimization strategies: current problems of immunosuppression. Transpl Int, 2015. 28: 891.
https://pubmed.ncbi.nlm.nih.gov/25752992
246. Jones-Hughes, T., *et al.* Immunosuppressive therapy for kidney transplantation in adults: a systematic review and economic model. Health Technol Assess, 2016. 20: 1.
https://pubmed.ncbi.nlm.nih.gov/27578428
247. Leas, B.F., *et al.*, in Calcineurin Inhibitors for Renal Transplant. 2016: Rockville (MD).
248. Sawinski, D., *et al.* Calcineurin Inhibitor Minimization, Conversion, Withdrawal, and Avoidance Strategies in Renal Transplantation: A Systematic Review and Meta-Analysis. Am J Transplant, 2016. 16: 2117.
https://pubmed.ncbi.nlm.nih.gov/26990455
249. Webster, A.C., *et al.* Tacrolimus versus ciclosporin as primary immunosuppression for kidney transplant recipients: meta-analysis and meta-regression of randomised trial data. BMJ, 2005. 331: 810.
https://pubmed.ncbi.nlm.nih.gov/16157605
250. Brunet, M., *et al.* Therapeutic Drug Monitoring of Tacrolimus-Personalized Therapy: Second Consensus Report. Ther Drug Monit, 2019. 41: 261.
https://pubmed.ncbi.nlm.nih.gov/31045868
251. Ekberg, H., *et al.* Relationship of tacrolimus exposure and mycophenolate mofetil dose with renal function after renal transplantation. Transplantation, 2011. 92: 82.
https://pubmed.ncbi.nlm.nih.gov/21562449

252. Xia, T., *et al.* Risk factors for calcineurin inhibitor nephrotoxicity after renal transplantation: a systematic review and meta-analysis. Drug Des Devel Ther, 2018. 12: 417.
https://pubmed.ncbi.nlm.nih.gov/29535503
253. Gallagher, M., *et al.* Cyclosporine withdrawal improves long-term graft survival in renal transplantation. Transplantation, 2009. 87: 1877.
https://pubmed.ncbi.nlm.nih.gov/19543068
254. Yang, K., *et al.* Systematic review and meta-analysis of calcineurin inhibitors on long-term prognosis of renal transplant patients. Transpl Immunol, 2022. 75: 101741.
https://pubmed.ncbi.nlm.nih.gov/36372141
255. Liu, J.Y., *et al.* Tacrolimus Versus Cyclosporine as Primary Immunosuppressant After Renal Transplantation: A Meta-Analysis and Economics Evaluation. Am J Ther, 2016. 23: e810.
https://pubmed.ncbi.nlm.nih.gov/25299636
256. Opelz, G., *et al.* Influence of immunosuppressive regimens on graft survival and secondary outcomes after kidney transplantation. Transplantation, 2009. 87: 795.
https://pubmed.ncbi.nlm.nih.gov/19300179
257. Cheung, C.Y., *et al.* Long-term graft function with tacrolimus and cyclosporine in renal transplantation: paired kidney analysis. Nephrology (Carlton), 2009. 14: 758.
https://pubmed.ncbi.nlm.nih.gov/20025685
258. de Fijter, J.W., et al. Early Conversion From Calcineurin Inhibitor- to Everolimus-Based Therapy Following Kidney Transplantation: Results of the Randomized ELEVATE Trial. Am J Transplant, 2017. 17: 1853.
https://pubmed.ncbi.nlm.nih.gov/28027625
259. Goring, S.M., *et al.* A network meta-analysis of the efficacy of belatacept, cyclosporine and tacrolimus for immunosuppression therapy in adult renal transplant recipients. Curr Med Res Opin, 2014. 30: 1473.
https://pubmed.ncbi.nlm.nih.gov/24628478
260. Pascual, J., *et al.* Everolimus with Reduced Calcineurin Inhibitor Exposure in Renal Transplantation. J Am Soc Nephrol, 2018. 29: 1979.
https://pubmed.ncbi.nlm.nih.gov/29752413
261. Basso, G., *et al.* The effect of anti-thymocyte globulin and everolimus on the kinetics of cytomegalovirus viral load in seropositive kidney transplant recipients without prophylaxis. Transpl Infect Dis, 2018. 20: e12919.
https://pubmed.ncbi.nlm.nih.gov/29797676
262. Bloom, R.D., *et al.* A randomized, crossover pharmacokinetic study comparing generic tacrolimus vs. the reference formulation in subpopulations of kidney transplant patients. Clin Transplant, 2013. 27: E685.
https://pubmed.ncbi.nlm.nih.gov/24118450
263. Glander, P., *et al.* Bioavailability and costs of once-daily and twice-daily tacrolimus formulations in *de novo* kidney transplantation. Clin Transplant, 2018. 32: e13311.
https://pubmed.ncbi.nlm.nih.gov/29888809
264. Guirado, L., *et al.* Medium-Term Renal Function in a Large Cohort of Stable Kidney Transplant Recipients Converted From Twice-Daily to Once-Daily Tacrolimus. Transplant Direct, 2015. 1: e24.
https://pubmed.ncbi.nlm.nih.gov/27500226
265. Melilli, E., *et al. De novo* use of a generic formulation of tacrolimus versus reference tacrolimus in kidney transplantation: evaluation of the clinical results, histology in protocol biopsies, and immunological monitoring. Transpl Int, 2015. 28: 1283.
https://pubmed.ncbi.nlm.nih.gov/26088437
266. Robertsen, I., *et al.* Use of generic tacrolimus in elderly renal transplant recipients: precaution is needed. Transplantation, 2015. 99: 528.
https://pubmed.ncbi.nlm.nih.gov/25148382
267. Rostaing, L., *et al.* Novel Once-Daily Extended-Release Tacrolimus Versus Twice-Daily Tacrolimus in *De Novo* Kidney Transplant Recipients: Two-Year Results of Phase 3, Double-Blind, Randomized Trial. Am J Kidney Dis, 2016. 67: 648.
https://pubmed.ncbi.nlm.nih.gov/26717860
268. Saengram, W., *et al.* Extended release versus immediate release tacrolimus in kidney transplant recipients: a systematic review and meta-analysis. Eur J Clin Pharmacol, 2018. 74: 1249.
https://pubmed.ncbi.nlm.nih.gov/29961086
269. Silva, H.T., Jr., *et al.* Long-term follow-up of a phase III clinical trial comparing tacrolimus extended-release/MMF, tacrolimus/MMF, and cyclosporine/MMF in *de novo* kidney transplant recipients. Transplantation, 2014. 97: 636.
https://pubmed.ncbi.nlm.nih.gov/24521771

270. Kahn, J., *et al.* Immunosuppression with generic tacrolimus in liver and kidney transplantation-systematic review and meta-analysis on biopsy-proven acute rejection and bioequivalence. Transpl Int, 2020. 33: 356.
https://pubmed.ncbi.nlm.nih.gov/31971288
271. Lehner, L.J., *et al.* Evaluation of adherence and tolerability of prolonged-release tacrolimus (Advagraf) in kidney transplant patients in Germany: A multicenter, noninterventional study. Clin Transplant, 2018. 32: e13142.
https://pubmed.ncbi.nlm.nih.gov/29052906
272. Paterson, T.S.E., *et al.* Impact of Once- Versus Twice-Daily Tacrolimus Dosing on Medication Adherence in Stable Renal Transplant Recipients: A Canadian Single-Center Randomized Controlled Trial. Can J Kidney Health Dis, 2019. 6: 2054358119867993.
https://pubmed.ncbi.nlm.nih.gov/31452902
273. Caillard, S., *et al.* Advagraf((R)) , a once-daily prolonged release tacrolimus formulation, in kidney transplantation: literature review and guidelines from a panel of experts. Transpl Int, 2016. 29: 860.
https://pubmed.ncbi.nlm.nih.gov/26373896
274. McCormack, P.L. Extended-release tacrolimus: a review of its use in *de novo* kidney transplantation. Drugs, 2014. 74: 2053.
https://pubmed.ncbi.nlm.nih.gov/25352392
275. Molnar, A.O., *et al.* Generic immunosuppression in solid organ transplantation: systematic review and meta-analysis. BMJ, 2015. 350: h3163.
https://pubmed.ncbi.nlm.nih.gov/26101226
276. Staatz, C.E., *et al.* Clinical Pharmacokinetics of Once-Daily Tacrolimus in Solid-Organ Transplant Patients. Clin Pharmacokinet, 2015. 54: 993.
https://pubmed.ncbi.nlm.nih.gov/26038096
277. van Gelder, T., *et al.* European Society for Organ Transplantation Advisory Committee recommendations on generic substitution of immunosuppressive drugs. Transpl Int, 2011. 24: 1135.
https://pubmed.ncbi.nlm.nih.gov/22032583
278. Wissing, K.M., *et al.* Prospective randomized study of conversion from tacrolimus to cyclosporine A to improve glucose metabolism in patients with posttransplant diabetes mellitus after renal transplantation. Am J Transplant, 2018. 18: 1726.
https://pubmed.ncbi.nlm.nih.gov/29337426
279. Diekmann, F. Immunosuppressive minimization with mTOR inhibitors and belatacept. Transpl Int, 2015. 28: 921.
https://pubmed.ncbi.nlm.nih.gov/25959589
280. Kamar, N., *et al.* Calcineurin inhibitor-sparing regimens based on mycophenolic acid after kidney transplantation. Transpl Int, 2015. 28: 928.
https://pubmed.ncbi.nlm.nih.gov/25557802
281. Park, S., *et al.* Reduced Tacrolimus Trough Level Is Reflected by Estimated Glomerular Filtration Rate (eGFR) Changes in Stable Renal Transplantation Recipients: Results of the OPTIMUM Phase 3 Randomized Controlled Study. Ann Transplant, 2018. 23: 401.
https://pubmed.ncbi.nlm.nih.gov/29891834
282. Sharif, A., *et al.* Meta-analysis of calcineurin-inhibitor-sparing regimens in kidney transplantation. J Am Soc Nephrol, 2011. 22: 2107.
https://pubmed.ncbi.nlm.nih.gov/21949096
283. Snanoudj, R., *et al.* Immunological risks of minimization strategies. Transpl Int, 2015. 28: 901.
https://pubmed.ncbi.nlm.nih.gov/25809144
284. Etienne, I., *et al.* A 50% reduction in cyclosporine exposure in stable renal transplant recipients: renal function benefits. Nephrol Dial Transplant, 2010. 25: 3096.
https://pubmed.ncbi.nlm.nih.gov/20299336
285. Budde, K., *et al.* Enteric-coated mycophenolate sodium. Expert Opin Drug Saf, 2010. 9: 981.
https://pubmed.ncbi.nlm.nih.gov/20795786
286. Cooper, M., *et al.* Enteric-coated mycophenolate sodium immunosuppression in renal transplant patients: efficacy and dosing. Transplant Rev (Orlando), 2012. 26: 233.
https://pubmed.ncbi.nlm.nih.gov/22863029
287. Staatz, C.E., *et al.* Pharmacology and toxicology of mycophenolate in organ transplant recipients: an update. Arch Toxicol, 2014. 88: 1351.
https://pubmed.ncbi.nlm.nih.gov/24792322
288. van Gelder, T., *et al.* Mycophenolate revisited. Transpl Int, 2015. 28: 508.
https://pubmed.ncbi.nlm.nih.gov/25758949

289. Wagner, M., *et al.* Mycophenolic acid versus azathioprine as primary immunosuppression for kidney transplant recipients. Cochrane Database Syst Rev, 2015: CD007746.
https://pubmed.ncbi.nlm.nih.gov/26633102
290. Hirsch, H.H., *et al.* European perspective on human polyomavirus infection, replication and disease in solid organ transplantation. Clin Microbiol Infect, 2014. 20 Suppl 7: 74.
https://pubmed.ncbi.nlm.nih.gov/24476010
291. Langone, A.J., *et al.* Enteric-coated mycophenolate sodium versus mycophenolate mofetil in renal transplant recipients experiencing gastrointestinal intolerance: a multicenter, double-blind, randomized study. Transplantation, 2011. 91: 470.
https://pubmed.ncbi.nlm.nih.gov/21245794
292. Doria, C., *et al.* Association of mycophenolic acid dose with efficacy and safety events in kidney transplant patients receiving tacrolimus: an analysis of the Mycophenolic acid Observational REnal transplant registry. Clin Transplant, 2012. 26: E602.
https://pubmed.ncbi.nlm.nih.gov/23121178
293. Langone, A., *et al.* Does reduction in mycophenolic acid dose compromise efficacy regardless of tacrolimus exposure level? An analysis of prospective data from the Mycophenolic Renal Transplant (MORE) Registry. Clin Transplant, 2013. 27: 15.
https://pubmed.ncbi.nlm.nih.gov/22861144
294. Su, V., *et al.* Impact of Mycophenolate Mofetil Dose Reduction on Allograft Outcomes in Kidney Transplant Recipients on Tacrolimus-Based Regimens: A Systematic Review. Ann Pharmacother, 2011. 45: 248.
https://pubmed.ncbi.nlm.nih.gov/21304036
295. Kotton, C.N., *et al.* Updated international consensus guidelines on the management of cytomegalovirus in solid-organ transplantation. Transplantation, 2013. 96: 333.
https://pubmed.ncbi.nlm.nih.gov/23896556
296. Le Meur, Y., *et al.* Therapeutic drug monitoring of mycophenolates in kidney transplantation: report of The Transplantation Society consensus meeting. Transplant Rev (Orlando), 2011. 25: 58.
https://pubmed.ncbi.nlm.nih.gov/21454067
297. Haller, M.C., *et al.* Steroid avoidance or withdrawal for kidney transplant recipients. Cochrane Database Syst Rev, 2016: CD005632.
https://pubmed.ncbi.nlm.nih.gov/27546100
298. Meier-Kriesche, H.U., *et al.* Mycophenolate mofetil initiation in renal transplant patients at different times posttransplantation: the TranCept Switch study. Transplantation, 2011. 91: 984.
https://pubmed.ncbi.nlm.nih.gov/21464796
299. Mathis, A.S., *et al.* Calcineurin inhibitor sparing strategies in renal transplantation, part one: Late sparing strategies. World J Transplant, 2014. 4: 57.
https://pubmed.ncbi.nlm.nih.gov/25032096
300. Remuzzi, G., *et al.* Mycophenolate mofetil versus azathioprine for prevention of chronic allograft dysfunction in renal transplantation: the MYSS follow-up randomized, controlled clinical trial. J Am Soc Nephrol, 2007. 18: 1973.
https://pubmed.ncbi.nlm.nih.gov/17460145
301. Kunz, R., *et al.* Maintenance therapy with triple versus double immunosuppressive regimen in renal transplantation: a meta-analysis. Transplantation, 1997. 63: 386.
https://pubmed.ncbi.nlm.nih.gov/9039928
302. Le Meur, Y., *et al.* Early steroid withdrawal and optimization of mycophenolic acid exposure in kidney transplant recipients receiving mycophenolate mofetil. Transplantation, 2011. 92: 1244.
https://pubmed.ncbi.nlm.nih.gov/22067312
303. Suszynski, T.M., *et al.* Prospective randomized trial of maintenance immunosuppression with rapid discontinuation of prednisone in adult kidney transplantation. Am J Transplant, 2013. 13: 961.
https://pubmed.ncbi.nlm.nih.gov/23432755
304. Thomusch, O., *et al.* Rabbit-ATG or basiliximab induction for rapid steroid withdrawal after renal transplantation (Harmony): an open-label, multicentre, randomised controlled trial. Lancet, 2016. 388: 3006.
https://pubmed.ncbi.nlm.nih.gov/27871759
305. Torres, A., *et al.* Randomized Controlled Trial Assessing the Impact of Tacrolimus Versus Cyclosporine on the Incidence of Posttransplant Diabetes Mellitus. Kidney Int Rep, 2018. 3: 1304.
https://pubmed.ncbi.nlm.nih.gov/30450457
306. Halleck, F., *et al.* An evaluation of sirolimus in renal transplantation. Expert Opin Drug Metab Toxicol, 2012. 8: 1337.
https://pubmed.ncbi.nlm.nih.gov/22928953

307. Ventura-Aguiar, P., *et al.* Safety of mTOR inhibitors in adult solid organ transplantation. Expert Opin Drug Saf, 2016. 15: 303.
https://pubmed.ncbi.nlm.nih.gov/26667069
308. Witzke, O., *et al.* Everolimus immunosuppression in kidney transplantation: What is the optimal strategy? Transplant Rev (Orlando), 2016. 30: 3.
https://pubmed.ncbi.nlm.nih.gov/26603484
309. Montero, N., *et al.* Mammalian Target of Rapamycin Inhibitors Combined With Calcineurin Inhibitors as Initial Immunosuppression in Renal Transplantation: A Meta-analysis. Transplantation, 2019. 103: 2031.
https://pubmed.ncbi.nlm.nih.gov/31343574
310. Badve, S.V., *et al.* Mammalian Target of Rapamycin Inhibitors and Clinical Outcomes in Adult Kidney Transplant Recipients. Clin J Am Soc Nephrol, 2016. 11: 1845.
https://pubmed.ncbi.nlm.nih.gov/27445164
311. Lim, W.H., *et al.* A systematic review of conversion from calcineurin inhibitor to mammalian target of rapamycin inhibitors for maintenance immunosuppression in kidney transplant recipients. Am J Transplant, 2014. 14: 2106.
https://pubmed.ncbi.nlm.nih.gov/25088685
312. Liu, J., *et al.* Efficacy and Safety of Everolimus for Maintenance Immunosuppression of Kidney Transplantation: A Meta-Analysis of Randomized Controlled Trials. PLoS One, 2017. 12: e0170246.
https://pubmed.ncbi.nlm.nih.gov/28107397
313. Knoll, G.A., *et al.* Effect of sirolimus on malignancy and survival after kidney transplantation: systematic review and meta-analysis of individual patient data. BMJ, 2014. 349: g6679.
https://pubmed.ncbi.nlm.nih.gov/25422259
314. Xie, X., *et al.* mTOR inhibitor versus mycophenolic acid as the primary immunosuppression regime combined with calcineurin inhibitor for kidney transplant recipients: a meta-analysis. BMC Nephrol, 2015. 16: 91.
https://pubmed.ncbi.nlm.nih.gov/26126806
315. Wolf, S., *et al.* Effects of mTOR-Is on malignancy and survival following renal transplantation: A systematic review and meta-analysis of randomized trials with a minimum follow-up of 24 months. PLoS One, 2018. 13: e0194975.
https://pubmed.ncbi.nlm.nih.gov/29659588
316. Hahn, D., *et al.* Target of rapamycin inhibitors (TOR-I; sirolimus and everolimus) for primary immunosuppression in kidney transplant recipients. Cochrane Database Syst Rev, 2019. 12: CD004290.
https://pubmed.ncbi.nlm.nih.gov/31840244
317. Shipkova, M., *et al.* Therapeutic Drug Monitoring of Everolimus: A Consensus Report. Ther Drug Monit, 2016. 38: 143.
https://pubmed.ncbi.nlm.nih.gov/26982492
318. Rostaing, L., *et al.* The pharmacokinetics of everolimus in *de novo* kidney transplant patients receiving tacrolimus: an analysis from the randomized ASSET study. Ann Transplant, 2014. 19: 337.
https://pubmed.ncbi.nlm.nih.gov/25017487
319. Shihab, F., *et al.* Association of Clinical Events With Everolimus Exposure in Kidney Transplant Patients Receiving Low Doses of Tacrolimus. Am J Transplant, 2017. 17: 2363.
https://pubmed.ncbi.nlm.nih.gov/28141897
320. Kumar, J., *et al.* Systematic Review on Role of Mammalian Target of Rapamycin Inhibitors as an Alternative to Calcineurin Inhibitors in Renal Transplant: Challenges and Window to Excel. Exp Clin Transplant, 2017. 15: 241.
https://pubmed.ncbi.nlm.nih.gov/27915965
321. Qazi, Y., *et al.* Efficacy and Safety of Everolimus Plus Low-Dose Tacrolimus Versus Mycophenolate Mofetil Plus Standard-Dose Tacrolimus in *De Novo* Renal Transplant Recipients: 12-Month Data. Am J Transplant, 2017. 17: 1358.
https://pubmed.ncbi.nlm.nih.gov/27775865
322. Rummo, O.O., *et al.* ADHERE: randomized controlled trial comparing renal function in *de novo* kidney transplant recipients receiving prolonged-release tacrolimus plus mycophenolate mofetil or sirolimus. Transpl Int, 2017. 30: 83.
https://pubmed.ncbi.nlm.nih.gov/27754567
323. Berger, S.P., *et al.* Two-year outcomes in *de novo* renal transplant recipients receiving everolimus-facilitated calcineurin inhibitor reduction regimen from the TRANSFORM study. Am J Transplant, 2019. 19: 3018.
https://pubmed.ncbi.nlm.nih.gov/31152476

324. Sommerer, C., *et al.* An open-label, randomized trial indicates that everolimus with tacrolimus or cyclosporine is comparable to standard immunosuppression in *de novo* kidney transplant patients. Kidney Int, 2019. 96: 231.
https://pubmed.ncbi.nlm.nih.gov/31027892
325. Tedesco-Silva, H., *et al.* Safety of Everolimus With Reduced Calcineurin Inhibitor Exposure in *De Novo* Kidney Transplants: An Analysis From the Randomized TRANSFORM Study. Transplantation, 2019. 103: 1953.
https://pubmed.ncbi.nlm.nih.gov/30801548
326. He, L., *et al.* Efficacy and safety of everolimus plus low-dose calcineurin inhibitor vs. mycophenolate mofetil plus standard-dose calcineurin inhibitor in renal transplant recipients: A systematic review and meta-analysis Clin Nephrol, 2018. 89: 336.
https://pubmed.ncbi.nlm.nih.gov/29292693
327. Liu, J.Y., *et al.* Sirolimus Versus Tacrolimus as Primary Immunosuppressant After Renal Transplantation: A Meta-Analysis and Economics Evaluation. Am J Ther, 2016. 23: e1720.
https://pubmed.ncbi.nlm.nih.gov/25569597
328. Zhao, D.Q., *et al.* Sirolimus-Based Immunosuppressive Regimens in Renal Transplantation: A Systemic Review. Transplant Proc, 2016. 48: 3.
https://pubmed.ncbi.nlm.nih.gov/26915834
329. Liefeldt, L., *et al.* Donor-specific HLA antibodies in a cohort comparing everolimus with cyclosporine after kidney transplantation. Am J Transplant, 2012. 12: 1192.
https://pubmed.ncbi.nlm.nih.gov/22300538
330. Wolf, S., *et al.* Infections after kidney transplantation: A comparison of mTOR-Is and CNIs as basic immunosuppressants. A systematic review and meta-analysis. Transpl Infect Dis, 2020. 22: e13267.
https://pubmed.ncbi.nlm.nih.gov/32072714
331. Halleck, F., *et al.* Transplantation: Sirolimus for secondary SCC prevention in renal transplantation. Nat Rev Nephrol, 2012. 8: 687.
https://pubmed.ncbi.nlm.nih.gov/23026948
332. Ponticelli, C., *et al.* Skin cancer in kidney transplant recipients. J Nephrol, 2014. 27: 385.
https://pubmed.ncbi.nlm.nih.gov/24809813
333. Cheung, C.Y., *et al.* Conversion to mammalian target of rapamycin inhibitors in kidney transplant recipients with *de novo* cancers. Oncotarget, 2017. 8: 44833.
https://pubmed.ncbi.nlm.nih.gov/28160552
334. Opelz, G., *et al.* Immunosuppression with mammalian target of rapamycin inhibitor and incidence of post-transplant cancer in kidney transplant recipients. Nephrol Dial Transplant, 2016. 31: 1360.
https://pubmed.ncbi.nlm.nih.gov/27190384
335. Liu, Y., *et al.* Basiliximab or antithymocyte globulin for induction therapy in kidney transplantation: a meta-analysis. Transplant Proc, 2010. 42: 1667.
https://pubmed.ncbi.nlm.nih.gov/20620496
336. Sun, Z.J., *et al.* Efficacy and Safety of Basiliximab Versus Daclizumab in Kidney Transplantation: A Meta-Analysis. Transplant Proc, 2015. 47: 2439.
https://pubmed.ncbi.nlm.nih.gov/26518947
337. Webster, A.C., *et al.* Interleukin 2 receptor antagonists for kidney transplant recipients. Cochrane Database Syst Rev, 2010: CD003897.
https://pubmed.ncbi.nlm.nih.gov/20091551
338. Lim, W., *et al.* Effect of interleukin-2 receptor antibody therapy on acute rejection risk and severity, long-term renal function, infection and malignancy-related mortality in renal transplant recipients. Transpl Int, 2010. 23: 1207.
https://pubmed.ncbi.nlm.nih.gov/20536789
339. McKeage, K., *et al.* Basiliximab: a review of its use as induction therapy in renal transplantation. BioDrugs, 2010. 24: 55.
https://pubmed.ncbi.nlm.nih.gov/20055533
340. Hellemans, R., *et al.* Induction Therapy for Kidney Transplant Recipients: Do We Still Need Anti-IL2 Receptor Monoclonal Antibodies? Am J Transplant, 2017. 17: 22.
https://pubmed.ncbi.nlm.nih.gov/27223882
341. Ali, H., *et al.* Rabbit anti-thymocyte globulin (rATG) versus IL-2 receptor antagonist induction therapies in tacrolimus-based immunosuppression era: a meta-analysis. Int Urol Nephrol, 2020. 52: 791.
https://pubmed.ncbi.nlm.nih.gov/32170593
342. Bamoulid, J., *et al.* Anti-thymocyte globulins in kidney transplantation: focus on current indications and long-term immunological side effects. Nephrol Dial Transplant, 2016.
https://pubmed.ncbi.nlm.nih.gov/27798202

343. Malvezzi, P., *et al.* Induction by anti-thymocyte globulins in kidney transplantation: a review of the literature and current usage. J Nephropathol, 2015. 4: 110.
https://pubmed.ncbi.nlm.nih.gov/26457257
344. Hill, P., *et al.* Polyclonal and monoclonal antibodies for induction therapy in kidney transplant recipients. Cochrane Database Syst Rev, 2017. 1: CD004759.
https://pubmed.ncbi.nlm.nih.gov/28073178
345. Webster, A.C., *et al.* Polyclonal and monoclonal antibodies for treating acute rejection episodes in kidney transplant recipients. Cochrane Database Syst Rev, 2017. 7: CD004756.
https://pubmed.ncbi.nlm.nih.gov/28731207
346. Gill, J., *et al.* Induction immunosuppressive therapy in the elderly kidney transplant recipient in the United States. Clin J Am Soc Nephrol, 2011. 6: 1168.
https://pubmed.ncbi.nlm.nih.gov/21511836
347. Lombardi, Y., *et al.* Belatacept in Kidney Transplantation: What Are the True Benefits? A Systematic Review. Front Med (Lausanne), 2022. 9: 942665.
https://pubmed.ncbi.nlm.nih.gov/35911396
348. Budde, K., *et al.* Conversion from Calcineurin Inhibitor- to Belatacept-Based Maintenance Immunosuppression in Renal Transplant Recipients: A Randomized Phase 3b Trial. J Am Soc Nephrol, 2021. 32: 3252.
https://pubmed.ncbi.nlm.nih.gov/34706967
349. Grinyo, J.M., *et al.* Belatacept utilization recommendations: an expert position. Expert Opin Drug Saf, 2013. 12: 111.
https://pubmed.ncbi.nlm.nih.gov/23206310
350. Wojciechowski, D., *et al.* Current status of costimulatory blockade in renal transplantation. Curr Opin Nephrol Hypertens, 2016. 25: 583.
https://pubmed.ncbi.nlm.nih.gov/27517137
351. Durrbach, A., *et al.* Long-Term Outcomes in Belatacept- Versus Cyclosporine-Treated Recipients of Extended Criteria Donor Kidneys: Final Results From BENEFIT-EXT, a Phase III Randomized Study. Am J Transplant, 2016. 16: 3192.
https://pubmed.ncbi.nlm.nih.gov/27130868
352. Vincenti, F., *et al.* Belatacept and Long-Term Outcomes in Kidney Transplantation. N Engl J Med, 2016. 374: 333.
https://pubmed.ncbi.nlm.nih.gov/26816011
353. de Graav, G.N., *et al.* A Randomized Controlled Clinical Trial Comparing Belatacept With Tacrolimus After *De Novo* Kidney Transplantation. Transplantation, 2017. 101: 2571.
https://pubmed.ncbi.nlm.nih.gov/28403127
354. Masson, P., *et al.* Belatacept for kidney transplant recipients. Cochrane Database Syst Rev, 2014. 2014: CD010699.
https://pubmed.ncbi.nlm.nih.gov/25416857
355. Talawila, N., *et al.* Does belatacept improve outcomes for kidney transplant recipients? A systematic review. Transpl Int, 2015. 28: 1251.
https://pubmed.ncbi.nlm.nih.gov/25965549
356. Bray, R.A., *et al. De novo* donor-specific antibodies in belatacept-treated vs cyclosporine-treated kidney-transplant recipients: *Post hoc* analyses of the randomized phase III BENEFIT and BENEFIT-EXT studies. Am J Transplant, 2018. 18: 1783.
https://pubmed.ncbi.nlm.nih.gov/29509295
357. Abdelwahab Elhamahmi, D., *et al.* Early Conversion to Belatacept in Kidney Transplant Recipients With Low Glomerular Filtration Rate. Transplantation, 2018. 102: 478.
https://pubmed.ncbi.nlm.nih.gov/29077658
358. Grinyo, J.M., *et al.* Safety and Efficacy Outcomes 3 Years After Switching to Belatacept From a Calcineurin Inhibitor in Kidney Transplant Recipients: Results From a Phase 2 Randomized Trial. Am J Kidney Dis, 2017. 69: 587.
https://pubmed.ncbi.nlm.nih.gov/27889299
359. Darres, A., *et al.* Conversion to Belatacept in Maintenance Kidney Transplant Patients: A Retrospective Multicenter European Study. Transplantation, 2018. 102: 1545.
https://pubmed.ncbi.nlm.nih.gov/29570163
360. Bamoulid, J., *et al.* Advances in pharmacotherapy to treat kidney transplant rejection. Expert Opin Pharmacother, 2015. 16: 1627.
https://pubmed.ncbi.nlm.nih.gov/26159444

361. Broecker, V., *et al.* The significance of histological diagnosis in renal allograft biopsies in 2014. Transpl Int, 2015. 28: 136.
https://pubmed.ncbi.nlm.nih.gov/25205033
362. Halloran, P.F., *et al.* Molecular assessment of disease states in kidney transplant biopsy samples. Nat Rev Nephrol, 2016. 12: 534.
https://pubmed.ncbi.nlm.nih.gov/27345248
363. Lentine, K.L., *et al.* The implications of acute rejection for allograft survival in contemporary U.S. kidney transplantation. Transplantation, 2012. 94: 369.
https://pubmed.ncbi.nlm.nih.gov/22836133
364. Clayton, P.A., *et al.* Long-Term Outcomes after Acute Rejection in Kidney Transplant Recipients: An ANZDATA Analysis. J Am Soc Nephrol, 2019. 30: 1697.
https://pubmed.ncbi.nlm.nih.gov/31308074
365. Halloran, P.F., *et al.* The Molecular Phenotype of Kidney Transplants: Insights From the MMDx Project. Transplantation, 2024. 108: 45.
https://pubmed.ncbi.nlm.nih.gov/37310258
366. Loupy, A., *et al.* The Banff 2019 Kidney Meeting Report (I): Updates on and clarification of criteria for T cell- and antibody-mediated rejection. Am J Transplant, 2020. 20: 2318.
https://pubmed.ncbi.nlm.nih.gov/32463180
367. Morgan, T.A., *et al.* Complications of Ultrasound-Guided Renal Transplant Biopsies. Am J Transplant, 2016. 16: 1298.
https://pubmed.ncbi.nlm.nih.gov/26601796
368. Redfield, R.R., *et al.* Nature, timing, and severity of complications from ultrasound-guided percutaneous renal transplant biopsy. Transpl Int, 2016. 29: 167.
https://pubmed.ncbi.nlm.nih.gov/26284692
369. Bouatou, Y., *et al.* Response to treatment and long-term outcomes in kidney transplant recipients with acute T cell-mediated rejection. Am J Transplant, 2019. 19: 1972.
https://pubmed.ncbi.nlm.nih.gov/30748089
370. Schinstock, C.A., *et al.* Recommended Treatment for Antibody-mediated Rejection After Kidney Transplantation: The 2019 Expert Consensus From the Transplantion Society Working Group. Transplantation, 2020. 104: 911.
https://pubmed.ncbi.nlm.nih.gov/31895348
371. Amore, A. Antibody-mediated rejection. Curr Opin Organ Transplant, 2015. 20: 536.
https://pubmed.ncbi.nlm.nih.gov/26348571
372. Burton, S.A., *et al.* Treatment of antibody-mediated rejection in renal transplant patients: a clinical practice survey. Clin Transplant, 2015. 29: 118.
https://pubmed.ncbi.nlm.nih.gov/25430052
373. Haririan, A. Current status of the evaluation and management of antibody-mediated rejection in kidney transplantation. Curr Opin Nephrol Hypertens, 2015. 24: 576.
https://pubmed.ncbi.nlm.nih.gov/26406806
374. Sautenet, B., *et al.* One-year Results of the Effects of Rituximab on Acute Antibody-Mediated Rejection in Renal Transplantation: RITUX ERAH, a Multicenter Double-blind Randomized Placebo-controlled Trial. Transplantation, 2016. 100: 391.
https://pubmed.ncbi.nlm.nih.gov/26555944
375. Loupy, A., *et al.* Antibody-Mediated Rejection of Solid-Organ Allografts. N Engl J Med, 2018. 379: 1150.
https://pubmed.ncbi.nlm.nih.gov/30231232
376. Wan, S.S., *et al.* The Treatment of Antibody-Mediated Rejection in Kidney Transplantation: An Updated Systematic Review and Meta-Analysis. Transplantation, 2018. 102: 557.
https://pubmed.ncbi.nlm.nih.gov/29315141
377. Kamar, N., *et al.* Incidence and predictive factors for infectious disease after rituximab therapy in kidney-transplant patients. Am J Transplant, 2010. 10: 89.
https://pubmed.ncbi.nlm.nih.gov/19656128
378. Velidedeoglu, E., *et al.* Summary of 2017 FDA Public Workshop: Antibody-mediated Rejection in Kidney Transplantation. Transplantation, 2018. 102: e257.
https://pubmed.ncbi.nlm.nih.gov/29470345
379. Farrugia, D., *et al.* Malignancy-related mortality following kidney transplantation is common. Kidney Int, 2014. 85: 1395.
https://pubmed.ncbi.nlm.nih.gov/24257690

380. Piselli, P., *et al.* Risk of *de novo* cancers after transplantation: results from a cohort of 7217 kidney transplant recipients, Italy 1997-2009. Eur J Cancer, 2013. 49: 336.
https://pubmed.ncbi.nlm.nih.gov/23062667
381. Jardine, A.G., *et al.* Prevention of cardiovascular disease in adult recipients of kidney transplants. Lancet, 2011. 378: 1419.
https://pubmed.ncbi.nlm.nih.gov/22000138
382. Liefeldt, L., *et al.* Risk factors for cardiovascular disease in renal transplant recipients and strategies to minimize risk. Transpl Int, 2010. 23: 1191.
https://pubmed.ncbi.nlm.nih.gov/21059108
383. Mellon, L., *et al.* Interventions for increasing immunosuppressant medication adherence in solid organ transplant recipients. Cochrane Database Syst Rev, 2022. 9: Cd012854.
https://pubmed.ncbi.nlm.nih.gov/36094829
384. Nankivell, B.J., *et al.* Diagnosis and prevention of chronic kidney allograft loss. Lancet, 2011. 378: 1428.
https://pubmed.ncbi.nlm.nih.gov/22000139
385. Boor, P., *et al.* Renal allograft fibrosis: biology and therapeutic targets. Am J Transplant, 2015. 15: 863.
https://pubmed.ncbi.nlm.nih.gov/25691290
386. Westall, G.P., *et al.* Antibody-mediated rejection. Curr Opin Organ Transplant, 2015. 20: 492.
https://pubmed.ncbi.nlm.nih.gov/26262460
387. Chapman, J.R. Chronic calcineurin inhibitor nephrotoxicity-lest we forget. Am J Transplant, 2011. 11: 693.
https://pubmed.ncbi.nlm.nih.gov/21446974

# 5. CONFLICT OF INTEREST

All members of the EAU Renal Transplantation Guidelines Panel have provided disclosure statements on all relationships that they have that might be perceived to be a potential source of a conflict of interest. This information is publically accessible through the EAU website: http://www.uroweb.org/guidelines/. These Guidelines were developed with the financial support of the EAU. No external sources of funding and support have been involved. The EAU is a non-profit organisation, and funding is limited to administrative assistance, travel and meeting expenses. No honoraria or other reimbursements have been provided.

# 6. CITATION INFORMATION

The format in which to cite the EAU Guidelines will vary depending on the style guide of the journal in which the citation appears. Accordingly, the number of authors or whether, for instance, to include the publisher, location, or an ISBN number may vary.

The compilation of the complete Guidelines should be referenced as:
*EAU Guidelines. Edn. presented at the EAU Annual Congress Paris 2024. ISBN 978-94-92671-23-3.*

If a publisher and/or location is required, include:
*EAU Guidelines Office, Arnhem, The Netherlands. http://uroweb.org/guidelines/compilations-of-all-guidelines/*

References to individual guidelines should be structured in the following way:
*Contributors' names. Title of resource. Publication type. ISBN. Publisher and publisher location, year.*

# 7. COPYRIGHT AND TERMS OF USE

The content of the EAU Guidelines and all products derived from them is made available for personal and educational use only. No commercial usage is authorised. No part of the EAU Guidelines or any related products may be translated or reproduced in any form without written permission from the EAU. Furthermore, the EAU prohibits the usage or upload of its Guidelines, and any material derived from these texts (whether in full or in part) on external websites, bots, pages, portals, servers, software, or external applications, including those employing artificial intelligence technologies and infrastructure, such as large language models and generative AI, deep learning and machine learning, unless written permission has been granted for such by the EAU.

The EAU accepts no responsibility for the content, quality, or performance of materials, applications and products derived from the EAU Guidelines and does not endorse or warrant their use. In the event of any discrepancies the original language version shall be considered authoritative.