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Review article

When and why to perform allograft nephrectomy? A systematic review from the AFU–SFT collaboration

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ABSTRACT

Allograft nephrectomy (AN) after graft failure remains controversial, balancing symptom control and facilitation of immunosuppression withdrawal against operative risk and uncertain immunological consequences. A systematic review of literature published from January 2000 to March 2024 in accordance with PRISMA guidelines was performed. We included studies addressing indications, timing, complications and outcomes related to subsequent transplantation. Thirty-nine studies were included. Reported prevalence varied widely but was <10% in most contemporary cohorts and declined after the cyclosporine era. Early AN was mainly performed for primary non-function, severe acute rejection, and surgical or vascular complications. Late transplantectomy was more often related to graft intolerance syndrome, refractory hypertension, or chronic infection. Overall morbidity was about 18% and mortality 4%, with higher risk in emergency settings. AN was not associated with improved recipient or graft survival after retransplantation, although it may increase sensitization and early graft-related events. In children, AN appeared more frequent than in adults, but evidence remained limited. Overall, AN appears to be an indication-driven rather than routine intervention, requiring individualized risk-benefit assessment within a retransplant strategy.

1. Introduction

Kidney transplantation is the treatment of choice for end-stage kidney disease, improving survival and quality of life, and offering a favorable medico-economic profile compared with dialysis [1–3]. Despite major advances in immunosuppression and post-transplant follow-up, kidney allografts rarely last a patient's lifetime. While short-term outcomes have markedly improved, long-term graft attrition remains a persistent challenge. In contemporary eras, overall graft survival for deceased-donor kidneys is approximately 50–55% at 10 years, indicating that a substantial proportion of recipients will ultimately experience graft failure and require re-initiation of kidney replacement therapy [4]. Although the leading cause of graft loss is patient death, the population of patients with a failed kidney allograft has been steadily increasing in recent years. In the United States, individuals with a failed kidney transplant account for approximately 4–5% of the incident dialysis population, as reported by the US Renal Data System [5]. Moreover, this population represents a substantial share of candidates listed for kidney transplantation (15%), highlighting the growing clinical and organizational impact of the failed allograft [5,6].

Patients returning to dialysis after kidney allograft failure represent a distinct high-risk population, with higher cardiovascular and infectious mortality than transplant-naïve incident dialysis patients [7]. Persistent inflammation, cumulative comorbidity, and ongoing immunosuppression with possible occult infection or immune activity within the failed graft may contribute to this excess risk. Once graft failure is established,

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clinicians face two interrelated decisions: how to manage immunosuppression and whether to retain or remove the failed allograft. In this context, transplant nephrectomy remains controversial: it can relieve graft intolerance syndrome and facilitate immunosuppression withdrawal but is an invasive procedure with non-negligible morbidity and mortality. Moreover, its immunological consequences, particularly regarding HLA sensitization and subsequent retransplantation, remain debated.

Against this backdrop, the Transplantation Committee of the French Association of Urology (AFU), in collaboration with the Francophone Society of Transplantation (SFT), undertook a systematic review of the literature on allograft nephrectomy (AN) in both adult and pediatric population. The aim of this review is to clarify the current evidence regarding the indications for AN after-kidney allograft failure, the optimal timing of the procedure, and its clinical impact, particularly with respect to outcomes after subsequent kidney retransplantation.

2. Methods

This systematic review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [8]. The protocol for this systematic review was prospectively registered in PROSPERO (International Prospective Register of Systematic Reviews; CRD420251040524).

2.1. Evidence acquisition

A systematic literature search was performed in PubMed/MEDLINE® to identify reports (in French or English) on AN, published between January 2000 and March 2024, in accordance with PRISMA criteria. The full search strategy is provided in Table S1. Study selection was based on PICOS criteria: Population (P): patients with graft failure after a first kidney transplantation, regardless of severity or age; Intervention (I): AN, encompassing different surgical techniques; Comparator (C): other surgical approaches, immunosuppression management strategies, dialysis, or embolization; Outcomes (O): morbidity and mortality (including cardiovascular and immunological impact), adverse events (myocardial infarction, congestive heart failure, sepsis, etc.), time to retransplantation or access to retransplantation, anatomical feasibility for retransplantation, quality of life, and acceptability; and (v) Study design (S): meta-analyses, randomized controlled trials, non-randomized prospective studies, or retrospective studies. Bibliographic data were complemented by literature monitoring (up to June 2024), consultation of international society websites (European Association of Urology, American Urological Association, British Transplantation Society, UK Kidney Association, American Society of Transplantation), a search for systematic reviews in the Cochrane Library database, and suggestions from the working group.

The search strategy was designed to address four predefined clinical questions: (1) the indications for AN and its optimal timing; (2) the immunological impact of AN and the management of immunosuppression before, during, and after the procedure; (3) surgical techniques for AN; and (4) alternatives to AN, including conservative management strategies. The present article reports the results of the literature selection and evidence synthesis related to the first question, focusing on indications and timing.

2.2. Eligibility criteria and study selection

Inclusion and exclusion criteria were predefined prior to the study. Only studies addressing the indications for AN regardless of disease severity or age were included. Publications deemed ineligible were: (i) health economic studies, as they largely depend on country-specific healthcare systems; (ii) case reports, narrative reviews, editorials, letters, or commentaries; (iii) experimental animal or in vitro studies; (iv) studies focusing on laboratory technology aspects; (v) studies on clinical practice patterns; and (vi) out-of-scope studies (e.g., not kidney-specific; public health topics not specific to kidney transplantation; immunosuppressive therapy efficacy; transplantation technique per se; donor nephrectomy techniques in living donors; dialysis modality; retransplantation per se; or primary non-function related to cancer).

Study selection was initially performed by the methodologist (DK) based on these criteria after abstract screening. The selection was independently validated by the steering committee (TC, AF, AG, TP, ADB) and subsequently by the full working group. Full texts of selected publications were then reviewed. Following an initial data extraction by the steering committee, the final set of included studies was confirmed by the steering committee, and any disagreements were resolved through discussion with the working group.

2.3. Quality assessment

The methodological quality of the included studies was evaluated using validated critical appraisal tools appropriate to each study design (e.g. randomized, prospective non-randomized or retrospective studies) that included the clinical relevance of the study objectives, clinical representativeness of the selected patients, relevance of the patients' inclusion and exclusion criteria, clinical relevance of the patients' recruitment period, independency between cohorts, blinded outcomes, potential confounding factors identified and considered in multivariate analyses, clinical relevance of the compared method, clinical relevance of the outcomes and their definition, funding/conflicts of interest. The risk of bias was assessed independently by two reviewers, and discrepancies were solved by consensus. Randomized and prospective non-randomized studies were prioritized in the analysis, and retrospective studies were included but interpreted with caution. This work was then reviewed by 33 independent experts from all medical and surgical specialties involved in the management of patients with renal graft failure (10 urologists, 4 nephrologists, 4 pediatric nephrologists, 3 immunologists, 3 vascular surgeons, 2 pediatric urologists, 1 pediatric surgeon, 1 infectiologist and 6 patient representatives). A summary of methodological analysis of included studies is presented in Table S2.

3. Results

Study selection is detailed in the PRISMA flow diagram (See Fig. 1). In total, 2144 records were screened for eligibility and 98 were selected. To address the question on the indications and timing of AN, after full-text review, additional literature checking, and suggestions from the working group, 39 studies were ultimately included for analysis: 3 systematic reviews/meta-analyses [9–11], 1 prospective study [12], 10 comparative studies [13–22], 22 observational studies [23–44], and 3 retrospective studies [45–47].

3.1. Epidemiology of allograft nephrectomy

The prevalence of AN varies widely across studies (1.26% to 43%), although in most series it remains below 10%. In a large historical cohort of 1866 kidney transplant recipients, Adhikary et al. reported a marked decline in AN rates after the introduction of cyclosporine in 1988. Specifically, the AN rate was significantly higher before 1988 than after (4.59% vs 1.26%; $p < 0.0001$). In the pre-cyclosporine era, AN was predominantly performed early (<6 months) (69.8% before 1988 vs 40% after; $p = 0.003$), mainly for hyperacute or acute rejection (48%) or infection (25.8%). In contrast, after 1988, it was more frequently performed late (>6 months) (3.2% before 1988 vs 60% after; $p = 0.000$) and was primarily related to chronic rejection (60%) [15].

3.2. Indications and timing: early Vs late allograft nephrectomy

A total of 15 studies assessing indications and/or timing of AN [13,16,21,23–27,32–35,37,47,48] (See Table 1). AN may be performed

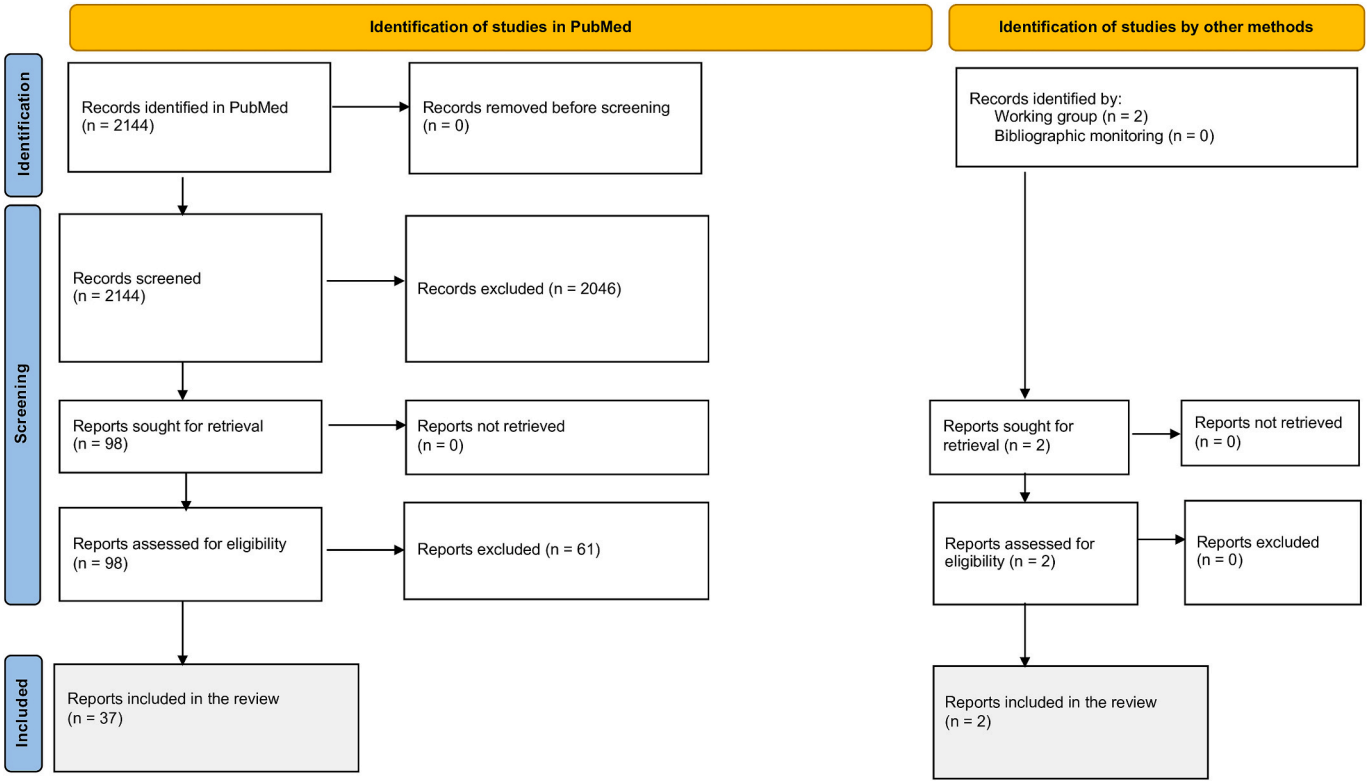

Fig. 1. PRISMA flow diagram.

Table 1
Indication and timing of kidney allograft transplantectomy (early vs late).

Study	Design	Population	AT, n (%)	Definition of timing threshold	Main indication - Early	Main indication - Late
Emiroglu et al. [13]	Comparative descriptive cohort	1,038 transplants	71 (6.8%)	6 months	Acute rejection (57.1%)	Graft tenderness and swelling (52%)
Mazzucchi et al. [16]	Retrospective observational	762 transplants	70 (9.2%)	2 months	Acute rejection (50%)	Chronic rejection (66%)
Sun et al. [21]	Retrospective comparative	NA	42	6 months	Acute rejection (71%)	Graft intolerance syndrome (95%)
Johnston et al. [23]	US MEDICARE registry (retrospective)	19,107 transplants	6,213 (32.5%)	12 months	NA	NA
Alberts et al. [24]	Retrospective observational	1,239 transplants	157 (12.7%)	NA	Non-functioning graft within 1 year (38%)	Symptomatic failed graft (pain 40%, fever 20%, hematuria 9%)
Zargar et al. [25]	Retrospective observational	1,228 transplants	60 (4.9%)	NA	Acute rejection	Chronic rejection (89%)
Secin et al. [26]	Retrospective observational	598 transplants	85 (14.5%)	NA	Acute rejection (28.6%)	Chronic rejection (58.2%)
Marinhox et al. [32]	Retrospective observational	777 transplants	30 (3.86%)	3 months	Vascular complications (50%)	NA
Guillaume et al. [33]	Retrospective observational	707 transplants	28 (4%)	1 month	Vascular complications (86%)	NA
Bunthof et al. [34]	retrospective	2,643 transplants	74 (25.7%)	6 months	NA	Graft intolerance syndrome (58%)
Üstün et al. [35]	Retrospective comparative	757 transplants	64 (8.4%)	56 days	Acute rejection (30%)	Chronic rejection (70.6%)
Freitas et al. [37]	retrospective comparative	1,213 transplants	104 (8.6%)	12 months	Vascular thrombosis (75%)	Chronic hematuria/pain (63.9%)
Grochowiecki et al. [47]	Retrospective comparative	291 allograft failure	120 (41%)	2 months	Vascular thrombosis (63%)	Fever (87.1%); graft pain (69.9%)
Goral et al. [48]	Retrospective histopathology serie	NA	73	3 months	Thrombosis/PNF predominant; haemorrhagic infarction; severe acute rejection (Banff grade 3)	Acute rejection (Banff 2B/3) with chronic lesions

Abbreviations: AT, allograft transplantectomy; NA, not available/not reported.

early or late after kidney transplantation depending on the underlying etiology. Various time thresholds have been reported in the literature (1, 2, 3, 6, and 12 months).

3.3. Early allograft nephrectomy

Early nephrectomy concerns a minority of recipients, with reported rates of approximately 4% in contemporary series when defined within the first month (3.96%) or the first 3 months (3.86%) after transplantation, with a mean time of 20 days. Indications are largely driven by early graft failure (primary non-function and acute rejection) and/or surgical complications, particularly vascular events (arterial/venous thrombosis, bleeding, graft rupture/hemorrhage). In the cohort reported by Marinhox et al., vascular complications, especially thrombotic events accounted for around 60% of indications for AN within the first 3 months. Reoperation within 10 days was associated with a reduced risk of early AN, suggesting that prompt diagnosis and management of postoperative complications may be critical [32]. Histopathology is consistent with this profile: AN performed within <3 months (median time of 4 days) are frequently associated with hemorrhagic infarction, and occasionally with severe acute rejection [48].

Table 2
Peri-operative morbidity and mortality after kidney allograft nephrectomy: summary of includedl studies.

Study (year)	Design (setting) / LoE*	Population (N transplantectomies)	Timing definition / comparison	Main indications (as reported)	Key morbidity outcomes	Mortality	Risk factors for morbidity/ mortality (as reported)
Mazzucchi et al. [16]	Retrospective comparative	70	<2 months vs >2 months	<2 months: antibody-mediated rejection (50%); >2 months: chronic nephropathy (66%)	Blood loss 434 vs 546 mL (p=0.02); major complications 0 vs 14.9% (p=0.05)	NA	NA
Sun et al. [21]	Retrospective	42	<6 months vs >6 months	Early: irreversible acute rejection (71%), PNF (29%); Late: graft intolerance (96%), graft tumour (4%)	Complications 59% vs 12% (p=0.01)	1 death reported (2.4%)	Anti-rejection therapy associated with complications in early group (OR=19.1; 95%CI 1.03-357)
Johnston et al. [23]	Registry/ administrative cohort (MEDICARE)	6 213	< 12 months vs > 12 months	NA	Higher complication burden with early graft failure; sepsis 10.7% vs 6.2% (p<0.0001)	90-day 5% Cardiovascular disease in 41% for early graft failure	Early graft failure associated with higher death risk (HR 1.13; 95% CI 1.01–1.26)
Alberts et al. [24]	Retrospective observational	143	NA	Graft failure within 1 year (38%); graft intolerance syndrome (57%)	Overall complications 25%; surgical complications 20%; 50% hemorrhagic; reoperation ≈ half of surgical complications	30-day 3%	None identified
Zargar et al. [25]	Retrospective observational	60	NA	Chronic rejection (88%)	Complication rate 5%	NA	NA
Secin et al. [26]	Retrospective observational	91	NA	NA	Morbidity 48.3% (95% CI 37.7–59); reoperation 10.9% (95% CI 5.3–19.2); hemorrhage predominant	7% (95% CI 2.6–14.7); sepsis main cause	Emergency surgery associated with higher morbidity (RR 1.9; 95% CI 1.3–2.7)
Ariyarathenam et al. [27]a	Retrospective observational	42	NA	Vascular thrombosis (50%); refractory acute rejection (24%)	Morbidity 31%	3-month 9.5%	NA
Bonilla et al. [36]	Retrospective observational	70	NA	Graft intolerance (59%); vascular thrombosis (16%)	Major complications (Clavien–Dindo III–IV) 21%	11%	Emergency surgery associated with major complications (HR =9.85; 95%CI 2.66-36.56) and death (HR=17.6; 95%CI 3.1-101)
Freitas et al. [37]	Retrospective comparative	104	<1 year vs >1 year	Early: vascular thrombosis (75%); Late: persistent haematuria and pain (64%)	Late associated with less blood loss (293 vs 414 mL; p=0.03), shorter LOS (12.8 vs 26.8 days; p=0.0005), fewer complications (22.2% vs 59.3%p=0.0001)	NA	NA
Grochowiecki et al. [47]	Retrospective comparative	120	<2 months vs >2	Early : nonfunctioning graft (93%); late: fever (87%) and pain (70%)	Different profiles: early rupture/ haemorrhagic–septic shock; late peritoneal breach/iliac artery injury; haematoma significantly higher late (27 vs 2; p<0.001)	0	NA
Srivastava et al. [49]	Retrospective comparative	46	<2 months vs >2 months	Early : acute rejection, vascular complication; late : graft intolerance	Vascular complications 18% vs 58%; infectious complications 48% vs 21%	NA	NA

* Abbreviations: CI, confidence interval; OR, Odds ratio; HR, hazard ratio; LOS, length of stay; NA, not available/not reported; PNF, primary non-function; RR, risk ratio.

3.4. Late allograft nephrectomy

Late AN reflects a different clinical picture, dominated by immuno-inflammatory and symptomatic indications. In series reporting etiology, rejection (chronic and/or acute) appears to be a major driver of procedures considered late. Zargar and Kamali reported chronic rejection as the primary indication (89%) with a mean time to nephrectomy of 5 years post-transplantation [25]. Secin et al. described an immunological indication in >80% of cases (chronic rejection 58.2%, acute rejection 28.6%), with a particularly high risk during the first 2 years after transplantation and within the first year after dialysis reinitiation [26]. Clinically, late nephrectomies are frequently prompted by graft intolerance syndrome (fever, graft pain/tenderness, hematuria), uncontrolled hypertension, or other persistent symptoms, as illustrated by Emiroğlu et al. (>6 months: fever or pain 26/50, hematuria 12/50, hypertension 7/50) and by Bunthof et al., in whom graft intolerance syndrome accounted for 58% of indications when transplantectomy was performed >6 months post-transplantation and > 3 months after graft functional loss [13,34]. Histological findings in nephrectomies performed >3 months (median time of 67 months) support this pattern, showing rejection-related lesions with chronic remodeling, advanced vascular lesions, and the presence of donor specific antigen (DSA) [48].

3.5. Morbidity and mortality

Morbidity and mortality was recorded in 11 studies [16,21,23–27,36,37,48,49] (See Table 2). Across series, AN is associated with non-negligible morbidity and mortality, with overall morbidity around 18% (range 5–59%) and mortality approximately 4% (range 0–38%), reflecting marked heterogeneity in case-mix, indications and timing of AN. Complications are mainly hemorrhagic (peri-operative bleeding, transfusion requirement and/or re-operation), but also include wound and deep surgical site infections, sepsis with multiorgan failure, and cardiovascular decompensation. A retrospective single-center series of 143 AN reported a 25% overall complication rate and a 3% 30-day mortality. Surgical complications occurred in 20%, and approximately half required re-operation [24]. In a cohort of 996 transplant recipients, including 70 transplantectomized patients, major complications (Clavien–Dindo III–IV) occurred in 21% and mortality reached 11%. Importantly, emergency surgery was strongly associated with major complications (HR = 9,85; 95%CI [2,66-36,56]) and death (HR = 17,6; 95%CI [3.1–101]) [36]. Consistently, Secin et al. reported high peri-operative morbidity (48%), re-operation (11%) and mortality (7%), with emergency AN associated with a significantly increased risk of complications (RR = 1.9; 95%CI [1.3–2.7]), and sepsis being a leading cause of death [26]. Timing may influence complication rates but is often confounded by indication: >1-year has been associated with less blood loss, shorter hospital stay and fewer complications than <1-year in a single-center series [37]. In the large North American MEDICARE-based analysis including 19,107 transplant recipients reported 6213 AN (32.5%), of which 33.7% occurred after early graft failure (<12 months). Ninety-day mortality was 5%, and AN in the setting of early graft failure was associated with a higher risk of death (HR 1.13; 95% CI [1.01–1.26]) [23]. Importantly, early versus late AN also differs in complications, mirroring underlying indications. Early procedures (often for vascular thrombosis, allograft rupture, bleeding or refractory rejection) being dominated by acute hemorrhagic events, whereas late procedures (often for graft intolerance, chronic infection or hematuria) more frequently involve infectious morbidity and re-dissection–related injuries. Overall, AN carries substantial surgical risk, particularly in early, urgent procedures and comorbid patients.

3.6. Impact of allograft nephrectomy on retransplant outcomes and patient survival

18 studies reporting impact of AN on kidney retransplant [9–11,14,17–19,28,31,38–46] (See Table 3). AN appears provides no consistent survival benefit after kidney retransplantation and is repeatedly associated with a signal of increased sensitization and early adverse graft events. In the meta-analysis by Wang et al. (8 studies, n = 1008), nephrectomy was not associated with differences in 1-year graft survival (OR = 0.74; 95%CI [0.31–1.72]), 1-year patient survival (OR = 1.60; 95%CI [0.57–4.46]), acute rejection (OR = 1.30; 95%CI [0.89–1.91]), postoperative complications (OR = 1.51; 95%CI [0.24–9.43]), or 1-year serum creatinine (Weight Mean Difference (WMD) = −0.25 mg/dl, p = 0.08). However, AN was associated with a longer graft-failure–to–retransplant interval (WMD = 11.23; p = 0.01) and higher rates of PRA >10% (OR = 1.62; 95%CI [1.17–2.23]) [11]. In the more recent meta-analysis by Gavriilidis et al. (16 retrospective studies, n = 2256), 5-year graft survival (HR = 1.11; 95%CI [0.89–1.38]) and 5-year overall survival (HR = 0.70; 95%CI [0.45–1.10]) were similar between groups, yet AN was associated with higher sensitization (Panel Reactivity antibody (PRA), 39% vs 35%; OR = 1.83; [95%CI 1.20–2.78]) and higher rates of delayed graft function (DGF) (OR = 1.86; 95%CI [1.16–2.98]), acute rejection (OR = 1.70; 95%CI [1.31–2.22]), primary non-function (PNF) (OR = 3.41; 95%CI [1,31-8,89]) and graft loss (OR = 1.51; 95%CI [1,09-2,09]), alongside longer cold ischemia time (WMD = 1.56 h; p = 0.02) [9]. Lin et al. (20 studies, n = 1802) reported better 3-year (OR = 0.48; 95%CI [0.34–0.69]) and 5-year graft survival (OR = 0.65; 95%CI [0.44–0.97]) in patients without nephrectomy, while AN was associated with higher PRA >10% (OR = 3.08; 95%CI [2.08–4.56]), acute rejection (OR = 1.59; 95%CI [1,21-2,09]) and DGF (OR = 1.66; 95%CI [1.20–2.03]) and longer cold ischemia time (WMD = 1.84 h; p = 0.0001); post-retransplant 5-year patient survival was paradoxically higher in the transplantectomy group (OR = 1.82; 95%CI [1.14–2.90]), finding likely vulnerable to selection and confounding [10].

Individual cohort studies largely suggest a neutral association between pre-retransplant AN and post-retransplant survival endpoints, while repeatedly highlighting a higher immunological risk profile. Ahmad et al. (n = 89) reported no differences in 1-, 3- and 5-year graft survival (p = 0.66) or 5-year patient survival (94.1% vs 87.5%; p = 0.69), with pre-retransplant PRA as the only independent predictor on graft and patient survival [42]. In Dinis et al. cohort (n = 126), 5-year patient (p = 0.55) and graft survival (p = 0.19) were similar, yet PRA positivity (38% vs 10%, $p < 0.001$) and acute rejection (19% vs 5.6%, p = 0.016) were higher after transplantectomy [38]. Other cohorts reported comparable graft survival despite higher PRA burden, longer dialysis exposure and/or more DGF in transplantectomized recipients [14,18]. Conversely, some series suggested worse early graft outcomes [17,41], whereas others reported improved post-retransplant patient survival [46] or no survival difference [31]. These cohort data underscore substantial heterogeneity in indications (graft intolerance vs urgency vs “space”), timing and surgical approach, as well as post-failure immunosuppression management and allocation factors (including cold ischemia time), all of which can confound comparisons between transplantectomy and non-transplantectomy groups.

Beyond post-retransplant outcomes, two large retrospective cohorts addressed patient survival after graft failure and return to dialysis, a complementary but distinct endpoint. In a registry-based cohort of 10,951 patients, Ayus et al. reported following propensity-score matching, an association between AN and lower all-cause mortality during follow-up (relative reduction 32%; 95%CI [26–37]), with higher subsequent retransplantation rates (10% vs 4.1%) [28]. However, this study did not assess graft or patient survival after retransplantation, and residual confounding and survivor selection bias. In a separate cohort, Muramatsu et al. suggested that survival after graft failure may be driven more by relisting than by AN timing, with wait-listing emerging as an independent predictor (RR = 0.17; 95%CI [0.06–0.41]) and early AN being associated with poorer survival than late AN, findings that are also vulnerable to confounding by indication and clinical urgency [45].

Table 3
Retransplant outcomes: summary of meta-analysis.

Study	Included studies / Sample size	Databases searched (n) Reviewers (n)	Intervention	Outcomes	Results
Wang et al. [11]	8 retrospective studies 1008 patients	5 databases 2 reviewers	Allograft nephrectomy vs no allograft nephrectomy	After retransplantation 1-year graft survival 1-year patient survival Acute rejection Postoperative complications Serum creatinine at 1 year	**1-year graft survival** OR=0.74; 95% CI [0.31-1.72]; p=0.48 **1-year patient survival** OR=1.60; 95% CI [0.57-4.46]; p=0.37 **Acute rejection** OR=1.30; 95% CI [0.89-1.91]; p=0.17 **Serum creatinine at 1 year** WMD: -0.25; 95% CI [-0.52 to 0.03]; p=0.08
Gavriilidis et al. [9]	16 retrospective studies 2256 patients	5 databases 2 reviewers	Allograft nephrectomy vs no allograft nephrectomy	After retransplantation 5-year graft survival 5-year overall survival %PRA Delayed graft function Acute rejection Primary non-function Graft loss Cold ischaemia time	**5-year graft survival** HR=1.11, 95% CI [0.89-1.38]; p=0.37 **5-year overall survival** HR=0.70; 95% CI [0.45-1.10]; p=0.12 **%PRA** OR=1.83; 95% CI [1.20-2.78]; p=0.005 **Delayed graft function** 39% vs 30%; OR=1.86; 95% CI [1.16-2.98]; p=0.01 **Acute rejection** OR=1.70; 95% CI [1.31-2.22]; p=0.001 **Primary non-function** OR=3.41; 95% CI [1.31-8.89]; p=0.001 **Graft loss** OR=1.51; 95% CI [1.09-2.09]; p=0.01 **Cold ischemia time** MD=1.56; 95% CI [0.28-2.85]; p=0.02
Lin et al. [10]	13 studies 1802 patients	3 databases 2 reviewers	Allograft nephrectomy vs no allograft nephrectomy	After retransplantation 3-5-year graft survival 5-year patient survival PRA >10% Acute rejection Delayed graft function Cold ischaemia time	**3-year graft survival** OR=0.48; 95% CI [0.34-0.69]; p<0.001 **5-year graft survival** OR=0.65; 95% CI [0.44-0.97]; p=0.04 **5-year patient survival** OR=1.82; 95% CI [1.14-2.90]; p=0.01 **PRA >10%** OR=3.08; 95% CI [2.08-4.56]; p=0.000 **Acute rejection** OR=1.59; 95% CI [1.21-2.09]; p=0.0009 **Delayed graft function** OR=1.66; 95% CI [1.20-2.03]; p=0.002 **Cold ischaemia time** MD=1.84; 95% CI [0.90-2.79]; p=0.0001

Abbreviations: CI, confidence interval; HR, hazard ratio; MD, mean difference; WMD, weighted mean difference; OR, odds ratio; PRA, panel reactive antibody.

3.7. Pediatric population

Pediatric evidence on AN is limited and retrospective, 3 studies, but suggests a high use after graft failure with timing- and indication-dependent patterns. In a multicenter cohort of 186 children with graft dysfunction, Verghese et al. reported AN in 76 patients (41%), occurring early in 24% (13% within the first week, 11% between day 7 and day 30), within 1 year in 29%, and beyond 1 year in 47%. Indications varied markedly: early procedures were mainly for graft thrombosis (80% in week 1, 63% within the first month), whereas late transplantectomy more often reflected graft intolerance and symptom control: painful graft distension (47%), refractory hypertension (19%), disease recurrence (11%), and, less commonly, hematuria/fever, immunosuppression minimization, space creation for retransplantation, or chronic pyelonephritis [12].

A pediatric-specific rationale is enabling immunosuppression discontinuation to reduce infection burden and growth impairment. In the Verghese cohort, AN was associated with higher rates of complete immunosuppression withdrawal (56% vs 26.5%, p ⟨0,0002). However, its immunologic and retransplant implications remain uncertain.

Verghese et al. did not demonstrate a reduction in anti-HLA sensitization or biopsy-proven acute rejection after retransplantation. Acute rejection episodes after retransplantation were reported more frequently among nephrectomized children, particularly when AN occurred >1-year post-transplant. Interpretation is constrained by heterogeneity in center practice, non-standardized endpoints, and confounding by indication.

Additional cohorts provide consistent but low-certainty signals. In an older single-center series (1977–1999), AN was performed in 84% of children after graft loss, with no perioperative deaths and postoperative morbidity dominated by wound and infectious complications. No clear difference in anti-HLA antibodies was observed according to transplantectomy status [50].

Overall, AN in children appears frequent after graft failure. Early for vascular events and later for intolerance/hypertension and immunosuppression withdrawal. Its effect on sensitization and retransplant outcomes remains unresolved.

4. Discussion

This systematic review on indications and timing of AN have been conducted to bring clear information for the 2025 French guidelines on AN: Indications and surgical techniques [51].

It shows that AN remains a clinically important intervention after graft failure, with a highly variable prevalence across studies (1.26–43%), although it is <10% in most contemporary cohorts. This heterogeneity likely reflects major difference in definitions, eras and center practices. Rates declined after the introduction of cyclosporine, with a shift from predominantly early nephrectomies for hyperacute and acute rejection or infection toward later procedures [15]. Overall, the evidence supports a pragmatic view, allograft nephrectomy should be considered an indication-driven, symptom- and complication-focused intervention rather than a routine step after graft failure. This is likely explained by an unproven risk–benefit balance, particularly with respect to the outcomes of subsequent retransplantation.

The literature supports a practical distinction between early and late nephrectomy, although thresholds vary (1, 2, 3, 6, or 12 months), limiting comparability. Early nephrectomy concerns a minority of recipients (4% when defined within 1–3 months). It is mostly performed for surgical or vascular complications and for early graft events (PNF, severe acute rejection). In contrast, late AN is predominantly indicated for graft intolerance syndrome and chronic infection or symptoms. Consistently, most studies suggest that late nephrectomy occur within the first year after return dialysis [23].

The review confirms that AN is not a benign intervention with overall morbidity around 18% (range 5–59%) and mortality approximately 4% (range 0–38%) across studies. Some reports suggest fewer complications when AN is performed late, this association is difficult to interpret because timing is inseparable from indication. “ Late ” often implies a more stable elective procedure, while “ early ” frequently implies urgency surgical complications or severe immune injury. Moreover, several cohorts have reported that emergency indication is strongly associated with an increased risk of major complications, reinterventions, and death [26,36]. These findings are probably strongly influenced by high-risk mortality of graft failure population [7].

One of the most clinically relevant messages of this review is that AN does not provide a consistent survival advantage after retransplantation, while it is repeatedly associated with higher sensitization and early graft events. Across meta-analyses and cohorts, post-retransplant patient and graft survival is generally similar between nephrectomy and non-nephrectomy groups, whereas markers of immunologic risk (PRA positivity) and early adverse graft outcomes (DGF, acute rejection, PNF, graft loss) are more frequently observed among nephrectomized patients [9–11]. However, interpretation requires caution. The nephrectomy group may be intrinsically different from the non-nephrectomy group, and/or data may be missing or inconsistently reported, particularly regarding: dialysis exposure after graft failure, allocation characteristics (including cold ischemia time, donor characteristics), immunosuppression management, sensitization kinetics (PRA, DSA and timing of antibody emergence), the indication for nephrectomy, and comorbidity burden and intercurrent events (infection, inflammation, transfusions), thereby limiting adjustment and increasing the risk of residual confounding. The recurrent association with higher sensitization nevertheless remains a practical concern for retransplant candidates. Although higher PRA positivity is frequently reported among transplantectomized recipients, the independent effect of AN is difficult to disentangle from post-failure immunosuppression management. Evidence suggests that immunosuppression discontinuation is a major driver of hyperimmunization, irrespective of nephrectomy [52]. Likewise, García Montemayor et al. suggested that DSA emergence after graft failure was more closely related to HLA mismatch burden and timing of immunosuppression cessation than to nephrectomy itself, with most DSA detected after withdrawal. Overall, sensitization appears driven primarily by alloimmune risk and immunosuppression strategy, rather than nephrectomy alone [53].

Data on survival after graft failure, irrespective of new transplantation, suggest a lower association between AN and mortality. This apparent association may reflect survivor bias, and available data suggest that survival after graft failure may be driven more by relisting and access to retransplantation than by nephrectomy itself [17,28].

In pediatric population, AN rates appear higher than in adults. Although evidence remains limited and heterogeneous, a recurring pediatric-specific rationale is the ability to withdraw immunosuppression earlier, potentially reducing infectious risk and mitigating growth impairment. However, robust comparative data on long-term immune sensitization and retransplant outcomes in pediatrics are sparse, and confounding by indication remains substantial.

This systematic review has limitations. Most included studies are retrospective, often single center, with limited sample size and substantial confounding. Critically, key variables are inconsistently reported, particularly post-failure immunosuppression management (timing and intensity of withdrawal), which is a major determinant of inflammation, sensitization, infection risk, and access to retransplantation. This heterogeneity explains why conclusions about the impact of AN on retransplant outcomes may appear contradictory across cohorts.

Finally, based on the available evidence and the working group discussion, AN remains a clinically important but non-benign procedure. Morbidity is substantial [11,24,25,27] (level of evidence 3 (LoE)), mortality is not negligible [9,11] (LoE3) [24,28,40] (LoE4), and both are increased in early and especially emergency settings [26,36] (LoE4). Hemorrhagic and infectious complications predominate [15,16,21,47,49] (LoE4). Current evidence does not support a clear benefit on recipient or graft survival after retransplantation [9,11] (LoE3), whereas other retransplant outcomes remain inconsistent. The increased sensitization burden observed after nephrectomy may, however, be clinically relevant in retransplant candidates [41] (LoE4) [9,11] (LoE3).

5. Conclusion

Allograft nephrectomy after kidney graft failure should be an indication-driven intervention (vascular or surgical complication, refractory graft intolerance syndrome, uncontrolled infection or symptoms). Current evidence does not demonstrate a benefit in post-retransplant graft survival or patient survival. AN is frequently associated with higher sensitization and adverse early events, yet the independent causal contribution of nephrectomy remains uncertain, as post-failure immunosuppression management appears to be a major determinant too. Accordingly, decisions should balance operative risk, indication, patient comorbidity, alternative methods, immunologic trajectory, and the retransplant plan, within an individualized, shared decision-making framework.

Declaration or generative AI and AI-assisted technologies in the manuscript

During the preparation of this work, the authors used ChatGPT by OpenAI to assist with scientific and medical English writing. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

Declaration of competing interest

The authors declare that they have no competing interests related to this scientific publication.

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Appendix A. Supplementary data

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