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Kidney Transplantation after Rescue Allocation - the Eurotransplant Experience: A Retrospective Multicenter Outcome Analysis

Running title: Kidney Transplantation after Rescue Allocation

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Abbreviations:

AM	acceptable mismatch program
CIT	cold ischemia time
CCO	competitive center offer
CMV	cytomegalovirus
DDRT	deceased donor renal transplantation
DwFG	death with functioning graft
ECD	expanded criteria donor
ET	Eurotransplant International Foundation, Leiden, The Netherlands
ETKAS	Eurotransplant Kidney Allocation System
ESP	Eurotransplant Senior Program
HR	hazard ratio
PNF	primary non-function
PRA	preformed antibodies
RA	rescue allocation
REAL	recipient oriented extended allocation
SA	standard allocation
SHR	subdistribution hazard ratio

ABSTRACT

Background: At Eurotransplant (ET), kidneys are transferred to ‘rescue allocation’ (RA), whenever the standard allocation (SA) algorithms Eurotransplant kidney allocation system (ETKAS) and Eurotransplant senior program (ESP) fail. We analyzed the outcome of RA.

Methods: Retrospective patient clinical and demographic characteristics association analyses with graft outcomes for 2,421 recipients of a deceased donor renal transplantation (DDRT) after RA versus 25,475 after SA from 71 centers across all ET countries from 2006 to 2018.

Results: Numbers of DDRTs after RA increased over the time, especially in Germany. RA played a minor role in ESP vs. ETKAS (2.7% vs. 10.4%). RA recipients and donors were older compared to SA recipients and donors, cold ischemia times were longer, waiting times were shorter, and the incidence of primary non-function was comparable. Among ETKAS-recipients, HLA matching was more favorable in SA (mean 3.7 vs. 2.5). In multivariate modeling, the incidence of death with a functioning graft (DwFG) in ETKAS was reduced in RA compared to SA (subdistribution hazard ratio 0.70, 95% confidence interval [0.60-0.81], p<0.001) whereas other outcomes (mortality, graft loss) were not significantly different. None of the three outcomes were significantly different when comparing RA with SA within the ESP program.

Conclusions: Facing increased waiting times and mortality on dialysis due to donor shortage, this study reveals encouragingly positive DDRT outcomes following RA. This supports the extension of RA to more patients and as an alternative tool to enable transplantation in patients in countries with prohibitively long waiting times or at risk of deterioration.

Supplemental Visual Abstract; http://links.lww.com/TP/C297

INTRODUCTION

Allocation schemes for deceased donor kidney transplantation (DDRT) are based on scientifically proven risk factors for graft and recipient outcome as well as ethical principles. These algorithms rank potential recipients on the waiting list for every allocation procedure. At the Eurotransplant International Foundation (ET), immunological matching, waiting time, cold ischemia time (CIT), age, urgency and preformed antibodies (PRA) are the defining factors [1-3].

Death on the ET waiting list ranges between 4.2% and 5.4% (mean 4.7%) for the last 15 years. This high mortality, which is a consequence of persistent and increasing donor shortage and high numbers of patients on the waiting list [4] resulted in the acceptance and transplantation of kidneys from comorbid donors with indefinite and disputable outcome. During the last two decades, 'expedited' or 'rescue allocation' (RA) rules have been established and refined repeatedly by most organizations worldwide to reduce the number of discarded grafts and increase transplant numbers [1-3]. Currently, 22.6% of all kidneys offered within ET are finally discarded and the median age of these donors is 61 years.

ET, the largest European organ allocation organization, defined distinct rules for RA following logistic and/or medical reasons which allow to deviate from the standard allocation (SA) programs 'Eurotransplant Kidney Allocation System' (ETKAS) and 'Eurotransplant Senior Program' (ESP)[2,5]. The ETKAS is destined for all candidates irrespective of their age and considers waiting time, HLA match, a regional/national bonus to favor shorter CITs, a pediatric bonus, and a high urgency bonus. However, the ESP is an alternative program only for candidates beyond 64 years of age, which abstains from HLA matching and only takes account of waiting time and preferably short CITs by regional allocation of kidneys from donors older than 64 years. Both SA programs transfer grafts to RA to prevent loss of potentially transplantable organs [5].

The reasons for switching over to RA may be very inhomogeneous and can derive from different reasons:

- repeated rejection of the offer for all candidates of five different centers e.g., due to donor-related reasons such as presumed inadequate quality of the graft or problems with the procurement process
- non-acceptance of the organ five hours after procurement
- logistics do not allow for a timely transplantation causing an increased CIT
- impending loss of the organ for transplantation
- or an interaction of these factors [2,6].

In addition, a subsequent ‘cascade effect’ of repeated declines has been reported in case of the subjective negative assessment of an offer and decline by one center [7].

However, even though kidneys offered via RA recently turned out to be of inferior histopathological quality [8] and characteristics of RA transplants are inhomogeneous, the outcome was demonstrated to be comparable to SA in small single center analyses [7,8].

In RA, centers may self-select suitable recipients by themselves either from an ET-generated ranking list within the Recipient Oriented Extended Allocation (REAL) program, which abides by the ETKAS SA criteria, or from an in-house list for Competitive Center Offers (CCO) [2], documenting the reasons for selecting the recipient for transparency and scrutiny. The detailed regulations on RA within ET can be looked up online in reference 5.

CCOs provide centers the opportunity to allocate grafts according to the match list or by specific in-house rules, such as urgency, need, or expected transplant outcome. The potential benefits from the transplantation of kidneys from expanded criteria donors (ECD) [9] to non-immunized recipients >40 years of age with diabetes and hypertension – the most perilous comorbidity cluster – have been described repeatedly [10-12]. A recent study showed that benefits of RA for selected recipients with impaired health status were most likely attributable to reduced waiting times [8], the strongest established modifiable risk factor for outcomes [13].

Current increases in both the number of kidneys offered via RA and the needs for donor kidneys across most countries, particularly in Europe, forces transplant physicians to identify and quantify the benefits of RA for selected target candidates. Hitherto, the outcomes from RA transplants have not been analyzed by comprehensive trials with sufficiently large case numbers. Therefore, this multicenter study was initiated to reveal the outcomes of RA from 71 ET kidney transplant centers in comparison to outcomes from SA within the same area.

MATERIALS AND METHODS

Long-term outcomes of RA kidney-only transplantations from brain death deceased donors (DDRT) within ETKAS and ESP in the ET area between January 2006 and May 2018 were investigated after approval of the study by the ET authorities (14046KAC14). During this time period a total of 50,835 SA and 3,498 RA DDRTs were performed.

All ET transplant centers were requested to return follow-up data to increase data completeness at the ET registry as previously performed by the ET community for comparable issues [14,15]. The request was issued between January and September 2019 and ascertained date of last follow-up, graft loss with date of loss, patient's death with date of death, as well as patient's death with functioning graft (DwFG), sequence of organ transplantation, and underlying renal disease, respectively. DwFG data provide insights into the concomitant health status of the affected recipients by accounting for the number of deaths not associated with graft failure. Information on sex, age at transplant, HLA match, waiting time, transplant period, country where the transplantation was performed, and general information on the overall ET waiting list and transplantations were obtained from the ET database.

Individual records with missing follow-up were assumed to have data missing at random and removed for statistical analyses [16], other exclusions are shown in Figure 1. Missing follow-up was defined, whenever no more information was available after transplantation. Cases with errors or contradictory information in the dataset were excluded as well. Non-informative censoring was assumed for all time-to-event analyses [17].

Within the investigated period and the restricted data set, 821 patients were repeatedly transplanted, including 179 RA patients. Re-transplantations were considered as independent observations. Mean (median) follow-up times for both SA- and RA-DDRTs were 1838.5 (1674) versus 1516.3 (1157) days, respectively. Follow-up acquisition was terminated on July 3rd, 2020 and reported follow-up was capped at 10 years after transplantation for all analyses. ET data protection policy required patient and center anonymization at the ET registry department, which provided anonymized data to the study statisticians and principal investigators.

Recipient survival was counted from day of transplant to day of death and not censored for graft loss. Graft loss was defined as return to dialysis after successful transplantation. All outcome parameters were censored for patient loss to follow-up. Cumulative incidence curves were calculated for recipient death, DwFG, and graft loss, the latter two accounting for competing risks of each other. Censored patient survival and cumulative incidence of DwFG and graft loss were compared for all investigated subgroups defined by clinical and demographic parameters. For factors with more than two groups in this analysis, Bonferroni correction was applied to account for multiple pairwise comparisons. For patient survival, Cox proportional hazards models were used [18]. For analyses of DwFG and graft loss, the Fine Gray proportional regression model was used with semiparametric random effects for competing risks [19-21]. Multivariable models for patient survival, DwFG, and graft loss included covariates previously identified [22] to affect graft failure and mortality after DDRT, such as age and gender of the recipient, waiting time, CIT, diabetes, transplant count, and HLA matches for comparison between RA and SA [4,8,13-15,23-27]. Both univariable and multivariable models were fit to all endpoints, with 95% CIs reported for hazard ratios. Primary non-function (PNF) was assumed when graft failure was recorded within 90 days after transplantation. Patients who died on the day of transplantation (SA: n=1; RA: n=1) and transplants with PNF were henceforth excluded from investigations on graft loss and DwFG.

The number of HLA matches including HLA-A, -B, and -DR loci was analyzed with regards to transplant outcome and further subdivided: all matches with at least one -DR plus at least one -A or one -B match were assigned to the group of 'favorable matches'; all others were defined as 'unfavorable matches'.

To account for relevant numbers of recipients with missing follow-up, a subgroup analysis was performed to determine statistically higher rates of missing follow-up with respect to the allocation modus. The chi square test with Monte Carlo simulations was used to test for differences in the categorical variables related to follow-up (Table S1 http://links.lww.com/TP/C296).

All analyses were performed at the two-sided level of significance of 0.05 using the R statistical package (R Foundation for Statistical Computing, Vienna, Austria) [21,28]. All data ascertainments and analyses were performed in accordance with ethical standards as laid down in the Declaration of Helsinki.

RESULTS

Demographic and transplant-specific data on SA and RA transplantations are given in Table 1 and the densities of recipient age for RA and SA are depicted in Figure 2A. The steep increase in SA recipients starting at 65 years originates from the ESP. RA recipients from the ETKAS waiting list as well as from the ESP list were significantly older than recipients after SA, received organs from older donors, had a worse HLA match and a prolonged CIT, but waiting time was shorter in each case. Notably, PNF-rates were comparable between SA and RA (Table 1). Considering recipients from the ETKAS waiting list only, the mean HLA match was higher for all HLA-A, -B, and -DR, in sum, and the frequency of favorable matches was superior (Table 2).

The numbers and proportions of RA increased markedly over the analyzed time periods (Figure 2B). Kidneys from RA were mainly allocated to candidates on the ETKAS waiting list and rarely for ESP-listed recipients (93.2% vs. 6.8%). RA played a minor role in ESP- as compared to ETKAS-listed patients (2.7% vs. 10.4%; Table 1). Germany had by far the most transplants within ET with respect to SA (59.1%), but especially with respect to RA (75.8%; Table 1).

With regards to cases with or without follow-up, no differences could be revealed for SA between left versus right organs, but significant differences were found for recipient age, donor age, allocation program, CIT, recipient sex, donor sex, renal disease, matching, waiting time, transplant count, transplantation period, and country. Among RA recipients, follow-up was less frequently noted in cases with unknown CIT, male donors, long waiting time, and later transplantation periods, and from Germany (Table S1 http://links.lww.com/TP/C296).

Table 3 gives an overview on patient survival, DwFG, and graft loss with regards to allocation modus and transplant-specific variables in univariate testing. Figure 3 displays the cumulative incidence curves of outcome of ETKAS-listed candidates with regards to RA vs. SA. Transplant outcome after RA between the different ET member countries did not reveal any statistical differences in subgroup analyses due to low case numbers in most countries (Table 1). However, waiting time of ETKAS-listed patients was by far the longest in Germany (mean 2410 days vs. <1600 days in all other ET member countries).

In univariate analyses, mortality and DwFG within ten years after RA were significantly higher as compared to SA for the analyzed period, but graft loss was similar (Table 3). Notably, patients with diabetes and prolonged waiting time displayed an increased mortality hazard and increased cumulative incidence of DwFG, but not with respect to graft loss. Survival and graft loss turned out to be worse in recipients of a second graft. DDRTs in recipients with cystic disease, favorable HLA match, organs from younger donors, and with shorter CITs showed superior outcomes in all three categories (Table 3).

The univariate analysis of transplant-specific continuous variables and the multivariate analysis of patient survival, DwFG, and graft loss of recipients from the ETKAS waiting list with regards to known influencing variables including the allocation modus can be found in

Table 4A and 4B. Remarkably, in the multivariate analysis both survival and graft loss after RA turned out to be comparable to SA (p=0.090 and p=0.885), whereas RA even showed reduced cumulative incidences for DwFG (subdistribution hazard ratio, SHR: 0.70; 95% CI: 0.60-0.81; p<0.001). Diabetes was associated with higher mortality and DwFG incidence. Re-transplantation was also associated with increased incidence of graft loss.

Notably, in subanalyses for recipients from the ESP waiting list, patient survival, DwFG and graft loss after RA were also comparable to SA (Table 4C). Furthermore, HLA match, CIT, and re-transplantation were not associated with any outcomes, whereas long waiting times as well as diabetes showed a positive association with mortality and DwFG.

Finally, the respective impact of the two crucial factors 'increasing donor age' and 'prolonged CIT' on patient survival, DwFG, and graft loss was exemplarily investigated for a fictitious reference recipient: 55-year-old, non-diabetic, female, favorable HLA match, waiting time of 5 years, and first transplantation (Table 5). In this prediction model, the risk of a prolonged CIT was markedly less critical than an older age of the donor.

DISCUSSION

Survival of recipients after DDRT has been demonstrated to be superior to that of patients on dialysis and candidates awaiting DDRT [4]. Shorter waiting time is the strongest modifiable factor for increasing transplant outcome [13]. Therefore, any candidate awaiting DDRT should ideally be transplanted as soon as possible and with an adequate graft. In contrast, organ shortages and demographic changes evidently impede this desirable goal. To cope with these challenges in kidney transplant supply and maintain acceptable transplant numbers, ET implemented the ESP and RA algorithms during the past decades. In contemporary practice, transplant physicians are pushed to accept kidneys from older donors with more comorbidities. The transplant outcomes of kidneys from ECDs have been repeatedly evaluated [10-12], revealing a survival benefit in unsensitized patients older than 40 years with diabetes or hypertension, particularly due to shortened waiting times [12], but data on survival and graft loss after RA DDRTs are scarce. Kidneys transplanted after RA have been reported to originate from older donors with a higher rate of diabetes, hypertension, fulfilled ECD criteria [6,8], and both increased acute and chronic histopathological changes were observed in zero-time biopsies from RA kidneys [8]. DDRTs after RA were characterized by a prolonged CIT, worse HLA matching, increased CMV transmission risk, but a reduced waiting time [8], which was validated by this study.

As the proportion of DDRT after RA increased markedly over time, this option apparently acquired greater importance in the ET kidney transplant centers. We therefore performed this comprehensive long-term ET multicenter study to resolve the question of RA DDRT outcome, thus far only addressed in single center reports [8,29,30].

Demographic and transplant specific characteristics of rescue-allocated DDRTs

This ET multicenter study confirmed the previously observed significantly older age of RA DDRT recipients and donors [8,29,30] in a comprehensive patient collective and even in case of distinction between ETKAS- and ESP-listed recipients. Notably, RA plays a minor role in recipients within the ESP until now (Table 1).

Considering the evidently crucial role of an 'excellent donor' and a favorable HLA match for younger recipients and the shorter waiting time within the ESP, it may be assumed that centers referred to RA especially in cases with an urgent need for a transplant due to deterioration and risk of delisting. Those patients typically suffer from comorbidities like hypertension and diabetes [8,11]. They are likely to be either too young to apply for the ESP (mean 57.4 years) to benefit from the shorter waiting time within this programme or already qualified for the ESP, but their advanced age (mean 69.3 years; Table 1) and limiting frailty [31] signal risk of imminent delisting. Considering this, transplant physicians obviously tended towards accepting RA offers, condoning increased donor age, prolonged CITs, and unfavorable HLA matching, just to escape this dilemma and shorten waiting time (Table 1). Despite the evidentially negative, though reasonable, compromises PNF turned out to be comparable between RA and SA as previously reported [8], which additionally encourages acceptance of RA offers. The question is whether a recommendation should be made for RA kidneys to be considered for more candidates apart from older patients and those with comorbidities, frailty, and an increased risk of delisting or higher risk of mortality after transplant [32-35].

Favorable HLA matching is essential for long-time graft and patient survival [15,23,27] and is credited with extra allocation points in the ETKAS, but ignored in the ESP [2], which concentrates on shorter CITs by regional allocation to reduce harm to organs from older donors [2]. This survey confirmed worse HLA matches and inferior HLA favorability of RA DDRTs of recipients listed within the ETKAS program (Table 2) [8,29]. Furthermore, less advantageous CMV-constellations were just recently identified in a single center study [8]. Taking this into account, preferring a recipient with a more favorable match in CCOs in future and assumingly better HLA matches in REAL versus CCO might even have an additional positive impact on outcome (Table 4B). Notably, right kidneys were significantly more frequent in RA which possibly might derive from apprehended technical problems due to the shorter vein and repeated decline in different centers [7]. Overall patient and graft outcome after RA including PNF was comparable to SA despite prolonged CITs, older recipient and donor age, inferior HLA matches, and assumingly higher CMV-risk. This observation must be ascribed to the pivotal impact of shortened waiting times in RA [8,13].

Use of kidney transplants from RA in the course of time and among ET countries

The increasing use of kidneys from RA, especially since 2014 (Figure 2B), correlates unambiguously with the mounting need for more grafts, which is aggravated by both the demographic change over the last decades and consecutively more comorbidities of the donors. Today, every tenth DDRT within the ET area originates from RA compared to a range of rates between 4.8% and 26.4% previously reported in single centers [7,8,29,30]. Furthermore, the effect of legal regulations concerning organ donation on the use of kidneys from RA was confirmed by this survey. The opting-in approach with its specific consent of the individual and deplorably low donation rates fosters the observed significantly longer waiting times and higher rate of RA in Germany (11%), whereas countries with the opting-out approach hardly use organs from RA (Table 1). However, despite an increased use of RA kidneys, decline rates of all kidneys offered before RA was initiated were comparable between the member states.

Facing the previously identified major benefit of shortened waiting times on transplant outcome [13] despite marginal grafts in RA [8,10-12] repeatedly declined in different centers for various reasons [7], DDRT through RA is reasonable and should be continued especially in countries with considerably prolonged waiting times due to organ shortage.

Rescue-allocated kidney recipient survival

Most encouragingly, multivariate analyses adjusting for potential confounding factors revealed comparable patient survival and decreased DwFG in ETKAS-listed recipients of RA versus SA DDRTs (Table 4B) despite worse recipient-, donor-, and transplant-specific characteristics in RA DDRT (Table 1). These results strongly encourage transplant physicians to continue DDRT via RA and debilitate any concerns of causing harm to recipients by use of RA grafts which might derive from the mentioned characteristics in RA and the univariate analysis (Table 3, Figure 3). According to our data, more attention should be directed to favorable HLA matching, younger donor age, and short CIT. Whenever possible, these factors should be taken into consideration and a recipient with a better HLA match should be prioritized in CCOs, especially in young recipients. Just recently, an easily practicable algorithm for acceptance of RA offers and careful selection of eligible RA recipients was demonstrated to yield excellent outcome [8]. Taken together, this offers the chance to include these variables into allocation (e.g. REAL), provide more safety to the centers concerning acceptance or decline, and improve RA outcome in future.

In the face of a limited pool of grafts, we urgently have to accelerate transportation and implement virtual crossmatching to reduce CITs whenever reasonable. Prospectively, even more RA grafts might be transplanted this way and allow for a reduction in waiting time – the key to reducing mortality [13].

Recipients with diabetic nephropathy and recipients of a re-transplantation showed inferior outcome in multivariate analyses as previously reported [10-12,15](Table 4B). If donor numbers markedly increased and waiting times decreased, survival of these poor prognosis patients could potentially increase.

According to the multivariate analysis, senior recipients of RA DDRT clearly profited from RA as survival and DwFG were comparable to SA. Notably, patient survival after RA was borderline significantly better compared to SA (Table 4C). These findings underline our explicit recommendation to continue and even extend RA use. In ESP-listed recipients, HLA matching and donor age had no impact on survival, but short waiting times were favorable, which facilitates the selection of appropriate RA recipients in this subgroup. Short waiting times must be expected to have a significant impact on outcome after DDRT and naturally prevent death on the waiting list in seniors.

Graft survival after rescue-allocated DDRTs

Fortunately, 10-year graft survival after RA DDRT was comparable to SA in the multivariate analysis even despite proven inferior histopathological acute and chronic tissue damages, worse HLA matching and elevated CMV-risk, longer CITs, older donor age, and significantly more adverse comorbidities and fulfilled ECD-criteria in RA donors as reported before [8]. Therefore, the acceptance of RA kidneys should be extended especially in countries with long waiting times. With regards to the multivariate analysis (Table 4B, C) and predictions (Table 5), all efforts need to be made to avoid loss of grafts from young donors by even accepting prolonged CITs. The effect of worse HLA matching and increased CMV transmission risk in RA [8] is apparently less weighty on overall graft outcome than expected.

In senior recipients graft survival after RA was equivalent to results from ESP SA and HLA matching may equally be neglected. Adding this to the excellent survival data, RA can be recommended for senior candidates as a potentially useful tool to provide these patients with a graft before deterioration, delisting, or death on the waiting list with increasing age and comorbidities in future [13,31,32,36].

Limitations

The major limitation of this study is the retrospective data assessment from a non-compulsory database. Contribution to data completeness differs between the ET member countries. While in some countries, including the Netherlands and Belgium, data reporting to ET is compulsory, in others, such as Germany, it is up to the centers. This explains the suboptimal data completeness in some parts, for example, the high rate of SA recipients without follow-up from Hungary and Germany. However, by use of statistical censoring, missing follow-up was correctly compensated for in the analyses and thanks to the participation of 71 transplant centers, data completeness was considerable after return of the questionnaires.

Unfortunately, relevant parameters, such as delayed graft function, rejection, biopsy-proven rejections, one-year glomerular filtration rate (GFR), concomitant diseases, and detailed donor features were not available. However, some of these issues can be assumed to be in accordance with results from previously published data like an increased one-year GFR [8,29,30]. Ideally, comprehensive reporting of these parameters would allow for subgroup analyses and enable identification of distinct candidates with a maximum profit of RA kidneys and particularly suitable donor-recipient combinations.

Finally, a tool including all relevant and available parameters to predict the expected benefit of RA in every single case over continuation of dialysis would be useful. An outcome predictor might even accelerate decision making in case of an offered organ via SA and potentially antedate RA initiation which would reduce the CIT and therefore help to improve outcomes. Furthermore, comprehensive data on discarded organs could help to identify kidneys that were unnecessarily discarded. Unfortunately, these data cannot be generated from the current ET database by now.

Conclusions

DDRTs of kidneys offered via RA should be expanded for both ETKAS- and ESP-listed recipients according to their excellent outcome in patient and graft survival, which is fully comparable to SA. The use of RA kidneys is an adequate extension of the donor pool and should be extended to increase transplant numbers and reduce waiting times. The acquiescence of longer CITs, less favorable HLA matching, and inferior histopathological renal parenchymal quality of RA kidneys is compensated by the weighty benefit of a significantly shorter waiting time. Although both ETKAS- and ESP-listed recipients profited from DDRT of RA grafts, we recommend to adhere to certain basic donor- and transplant-specific parameters such as careful consideration of proteinuria, hypertension, and diabetes of the donor and a limited donor-recipient age difference like previously recommended [8]. In CCOs for younger recipients, a patient with a favorable HLA match should be preferred over a candidate with an unfavorable match and even despite a potentially prolonged CIT in case of a young donor to further increase the outcome according to our data.

In ESP recipients, however, these considerations are secondary; the shortened waiting time in RA becomes even more attractive in the race against deterioration whilst waiting for SA, consecutively making RA a perfect supplement to the ESP.

This study clearly indicates that a mandatory joined register to collect all data on donors and recipients, including for example, concomitant diseases, is urgently needed to identify those candidates who do or do not profit from RA, enabling transplant physicians offered a RA kidney to separate the wheat from the chaff. Apart from these factors, our allocation procedures and organ logistics must become quicker and virtual crossmatching has to be implemented to reduce CITs and thus improve the quality of all grafts.

In the meantime, transplant centers should individually define or revise their center specific criteria for RA transplants, if not yet done.

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Legends to figures and tables

Figure 1: Flowchart of selection process of transplants analyzed in this study. Counts refer to number of transplants. ETKAS: Eurotransplant Kidney Allocation System; ESP: Eurotransplant Senior Program; AM: Acceptable Mismatch Program.

Figure 2: **(A)** Recipient age and **(B)** amount of transplants between 2006 and 2018 with respect to allocation type. Percentages show the fraction of the respective period.

Figure 3: Cumulative incidence curves for ETKAS patients with respect to death (A), death with functioning graft (B), and graft loss (C) according to allocation.

Table 1: Characteristics of transplants according to allocation.

Characteristics of ETKAS and ESP transplants								
		Standard allocation			**Rescue allocation**			
	Value	N (25475)	Group %	Allocation %	N (2421)	Group %	Allocation %	p-value
Recipient sex	Female	9161	36.0	90.7	935	38.6	9.3	0.010
	Male	16314	64.0	91.7	1486	61.4	8.3	
Disease group	Glomerulo-nephritis	5891	23.1	91.3	558	23.0	8.7	<0.001
	Cystic disease	3429	13.5	89.8	390	16.1	10.2	
	Diabetes	2160	8.5	90.6	225	9.3	9.4	
	Other	13995	54.9	91.8	1248	51.5	8.2	
Donor sex	Female	12057	47.3	91.7	1088	44.9	8.3	0.026
	Male	13418	52.7	91.0	1333	55.1	9.0	
Allocation program	ETKAS	19516	76.6	89.6	2257	93.2	10.4	<0.001
	ESP	5959	23.4	97.3	164	6.8	2.7	
Organ	Left kidney	12381	48.6	91.8	1100	45.4	8.2	0.003
	Right kidney	13094	51.4	90.8	1321	54.6	9.2	

Transplant count	1	23547	92.4	91.4	2224	91.9	8.6	0.266
	2	1807	7.1	90.5	189	7.8	9.5	
	≥3	121	0.5	93.8	8	0.3	6.2	
Country	Germany	15060	59.1	89.1	1836	75.8	10.9	<0.001
	Austria	3066	12.0	92.5	247	10.2	7.5	
	Belgium	2920	11.5	97.8	65	2.7	2.2	
	Netherlands	1972	7.7	94.3	119	4.9	5.7	
	Croatia	1764	6.9	96.0	74	3.1	4.0	
	Slovenia	498	2.0	95.0	26	1.1	5.0	
	Hungary	171	0.7	76.0	54	2.2	24.0	
	Luxembourg	24	0.1	100.0	0	0.0	0.0	
Sum of HLA matches	0	271	1.3	70.9	111	5.4	29.1	<0.001
	1	1022	4.8	75.1	338	16.3	24.9	
	2	3130	14.7	83.1	638	30.8	16.9	
	3	7148	33.5	92.3	596	28.8	7.7	
	4	5087	23.8	94.3	307	14.8	5.7	
	5	1308	6.1	95.1	67	3.2	4.9	
	6	3389	15.9	99.6	13	0.6	0.4	
	Missing	4120		92.1	351		7.9	
HLA match grouping	favorable	18365	86.0	93.3	1310	63.3	6.7	<0.001
	non-favorable	2990	14.0	79.7	760	36.7	20.3	
	Missing	4120		92.1	351		7.9	

Dead	No	19681	77.3	91.1	1923	79.4	8.9	0.016
	Yes	5794	22.7	92.1	498	20.6	7.9	
Failure	No	23417	91.9	91.4	2207	91.2	8.6	0.204
	Yes	2058	8.1	90.6	214	8.8	9.4	
DwFG	No	20109	78.9	91.1	1964	81.1	8.9	0.012
	Yes	5366	21.1	92.2	457	18.9	7.8	
PNF	No	25031	98.3	91.4	2368	97.8	8.6	0.132
	Yes	444	1.7	89.3	53	2.2	10.7	

Characteristics of ETKAS transplants

	Standard allocation			**Rescue allocation**			
	Count (Missing)	Quartiles [range]	Mean ± SD	Count (Missing)	Quartiles [range]	Mean ± SD	p-value
Recipient age	19516 (0)	52 [43, 59]	50.2 ± 11.9	2257 (0)	58 [51, 64]	56.6 ± 10.7	<0.001
Donor age	19516 (0)	50 [41, 58]	47.6 ± 13.9	2257 (0)	58 [48, 68]	56.1 ± 17.1	<0.001
Cold ischemia time [min]	16319 (3197)	810 [612, 1020]	832.5 ± 308	2058 (199)	1002.5 [772.2, 1260]	1032.3 ± 361.8	<0.001
Waiting time [days]	19516 (0)	1867 [1006, 2793]	1989.9 ± 1211.5	2257 (0)	1533 [823, 2416]	1681.6 ± 1020.4	<0.001

Characteristics of ESP transplants							
	Standard allocation			**Rescue allocation**			
	Count (Missing)	Quartiles [range]	Mean ± SD	Count (Missing)	Quartiles [range]	Mean ± SD	p-value
Recipient age	5959 (0)	68 [66, 71]	68.7 ± 3.4	164 (0)	69 [67, 72]	69.3 ± 3.3	0.007
Donor age	5959 (0)	71 [67, 74]	71.3 ± 4.8	164 (0)	76 [71, 81]	76.3 ± 6.8	<0.001
Cold ischemia time [min]	5369 (590)	635 [468, 822]	665.1 ± 259.9	145 (19)	880 [669, 1080]	897.1 ± 285.3	<0.001
Waiting time [days]	5959 (0)	1258 [809.5,1813]	1368.5 ± 736.6	164 (0)	815 [528.2, 1409]	1058.1 ± 726.2	<0.001

ETKAS (Eurotransplant Kidney Allocation System), ESP (Eurotransplant Senior Program), DwFG (death with functioning graft), PNF (primary non-function).

Table 2: Comparison of HLA matching between allocation types limited to ETKAS data

		Standard allocation			Rescue allocation			
	Value	N	%		N	%		p-value
HLA-A matches	0	1904	9.8		436	19.3		<0.001
	1	9522	48.8		1188	52.6		
	2	8085	41.4		380	16.8		
	Missing	5	0.0		253	11.2		
	Mean			1.3			1.0	
HLA-B matches	0	3540	18.1		878	38.9		<0.001
	1	10511	53.9		977	43.3		
	2	5460	28.0		149	6.6		
	Missing	5	0.0		253	11.2		
	Mean			1.1			0.6	
HLA-DR matches	0	1635	8.4		604	26.8		<0.001
	1	10742	55.0		1100	48.7		
	2	7134	36.6		300	13.3		
	Missing	5	0.0		253	11.2		
	Mean			1.3			0.8	
Sum of HLA matches	0	82	0.4		102	4.5		<0.001
	1	530	2.7		317	14.0		
	2	2625	13.5		613	27.2		

	3	6757	34.6	594	26.3	
	4	4884	25.0	304	13.5	
	5	1252	6.4	62	2.7	
	6	3381	17.3	12	0.5	
	Missing	5	0.0	253	11.2	
	Mean		3.7		2.5	
HLA match grouping	favorable	17518	89.8	1287	57.0	<0.001
	non-favorable	1993	10.2	717	31.8	
	Missing	5	0.0	253	11.2	

Table 3: Univariate analysis of factors regarding survival and competing risk between DwFG (death with functioning graft) and graft loss of ETKAS transplants. For patient survival, Cox proportional hazards models and, for DwFG and graft loss, the Fine Gray proportional regression models were used. P-values show the significance of hazard ratios in the case of survival and of subdistributional hazard ratios in the case of DwFG and graft loss for pairwise comparisons of values (dotted line: p<0.05, dashed line: p<0.01, solid line: p<0.001)

Univariate outcome analysis				Availability survival		Survival estimate				Availability DwFG/graft loss		Cumulative incidence of DwFG				Cumulative incidence of graft loss			
				Pat.	Compl.	1y	5y	10y	p-value.	Pat.	Compl.	1y	5y	10y	p-value.	1y	5y	10y	p-value.
		N	%	N	%	% ± SE	% ± SE	% ± SE		N	%	% ± SE	% ± SE	% ± SE		% ± SE	% ± SE	% ± SE	
Allocation type																			
	Standard	23688	90.3	19516	82.4	96.3 ± 0.1	86.9 ± 0.3	72.0 ± 0.5		19181	81.0	3.7 ± 0.1	12.5 ± 0.3	25.7 ± 0.5		1.4 ± 0.1	5.1 ± 0.2	12.0 ± 0.4	

	Rescue	2553	9.7	2257	88.4	95.1 ± 0.5	80.6 ± 1.0	62.3 ± 1.9		2209	86.5	4.8 ± 0.5	18.3 ± 1.0	34.7 ± 1.8		2.0 ± 0.3	7.6 ± 0.7	12.7 ± 1.1
Donor sex																		
	Female	11797	45.0	9867	83.6	95.9 ± 0.2	85.9 ± 0.4	70.1 ± 0.7		9670	82.0	4.1 ± 0.2	13.4 ± 0.4	27.4 ± 0.7		1.6 ± 0.1	5.6 ± 0.3	12.9 ± 0.5
	Male	14444	55.0	11906	82.4	96.4 ± 0.2	86.6 ± 0.4	72.1 ± 0.7		11720	81.1	3.5 ± 0.2	12.8 ± 0.4	25.6 ± 0.6		1.4 ± 0.1	5.1 ± 0.2	11.5 ± 0.5
Recipient sex																		
	Female	9933	37.9	8199	82.5	96.3 ± 0.2	87.6 ± 0.4	72.9 ± 0.8		8042	81.0	3.6 ± 0.2	11.6 ± 0.4	24.5 ± 0.7		1.4 ± 0.1	5.6 ± 0.3	12.9 ± 0.6
	Male	16308	62.1	13574	83.2	96.1 ± 0.2	85.5 ± 0.4	70.1 ± 0.6		13348	81.8	3.9 ± 0.2	14.0 ± 0.3	27.7 ± 0.6		1.5 ± 0.1	5.2 ± 0.2	11.6 ± 0.4

Organ																
	Left kidney	12556	47.8	10380	82.7	96.3 ± 0.2	86.6 ± 0.4	71.7 ± 0.7	10209	81.3	3.7 ± 0.2	12.9 ± 0.4	25.8 ± 0.7	1.5 ± 0.1	5.3 ± 0.3	12.2 ± 0.5
	Right kidney	13685	52.2	11393	83.3	96.1 ± 0.2	86.1 ± 0.4	70.7 ± 0.7	11181	81.7	3.9 ± 0.2	13.2 ± 0.4	27.0 ± 0.7	1.5 ± 0.1	5.3 ± 0.2	12.1 ± 0.5
Disease group																
	Glomerulo-nephritis	6160	23.5	5175	84.0	96.7 ± 0.3	87.8 ± 0.5	74.4 ± 1.0	5073	82.4	3.3 ± 0.3	11.4 ± 0.5	23.1 ± 0.9	1.5 ± 0.2	6.0 ± 0.4	13.7 ± 0.8
	Cystic disease	3741	14.3	3060	81.8	97.1 ± 0.3	89.8 ± 0.6	76.0 ± 1.2	3012	80.5	2.9 ± 0.3	9.8 ± 0.6	22.6 ± 1.2	1.5 ± 0.2	4.2 ± 0.4	10.0 ± 0.9
	Diabetes	1836	7.0	1530	83.3	92.2 ± 0.7	70.3 ± 1.4	40.6 ± 2.3	1501	81.8	7.8 ± 0.7	28.6 ± 1.4	56.6 ± 2.3	1.4 ± 0.3	2.9 ± 0.5	4.5 ± 0.8

	Other	14504	55.3	12008	82.8	96.3 ± 0.2	86.7 ± 0.4	72.1 ± 0.7	11804	81.4	3.7 ± 0.2	12.7 ± 0.4	25.4 ± 0.6	1.5 ± 0.1	5.6 ± 0.2	12.9 ± 0.5
Favourability	favorable	22734	86.6	18805	82.7	96.4 ± 0.1	87.0 ± 0.3	72.1 ± 0.5	18488	81.3	3.6 ± 0.1	12.4 ± 0.3	25.6 ± 0.5	1.4 ± 0.1	5.0 ± 0.2	11.7 ± 0.4
	non-favorable	3220	12.3	2710	84.2	95.7 ± 0.4	83.2 ± 0.8	66.9 ± 1.5	2648	82.2	4.3 ± 0.4	15.9 ± 0.8	30.3 ± 1.5	2.3 ± 0.3	7.3 ± 0.6	15.8 ± 1.2
	Missing	287	1.1	258	89.9	89.2 ± 2.0	61.5 ± 3.8	42.2 ± 6.5	254	88.5	11.0 ± 2.0	37.4 ± 3.8	53.3 ± 6.2	0.8 ± 0.6	4.3 ± 1.6	7.8 ± 2.5
Transplantation period	2006-2009	9188	35.0	8261	89.9	95.8 ± 0.2	86.8 ± 0.4	72.4 ± 0.6	8120	88.4	4.2 ± 0.2	12.5 ± 0.4	25.5 ± 0.6	1.4 ± 0.1	4.9 ± 0.3	10.8 ± 0.4

	2010-2013	8174	31.1	7354	90.0	96.4 ± 0.2	87.3 ± 0.4	69.4 ± 1.5	7222	88.4	3.6 ± 0.2	12.2 ± 0.4	28.1 ± 1.4	1.3 ± 0.1	4.6 ± 0.3	15.9 ± 1.3
	2014-2018	8879	33.8	6158	69.4	96.5 ± 0.2	80.3 ± 1.0		6048	68.1	3.5 ± 0.2	18.9 ± 1.0		1.8 ± 0.2	8.9 ± 0.7	
Transplant count	1	24185	92.2	20001	82.7	96.3 ± 0.1	86.6 ± 0.3	71.6 ± 0.5	19649	81.2	3.7 ± 0.1	12.8 ± 0.3	26.1 ± 0.5	1.5 ± 0.1	5.1 ± 0.2	11.7 ± 0.4
	2	1919	7.3	1654	86.2	95.4 ± 0.5	83.2 ± 1.1	66.3 ± 2.0	1627	84.8	4.7 ± 0.5	16.4 ± 1.1	31.1 ± 1.9	1.4 ± 0.3	8.0 ± 0.8	16.7 ± 1.5
	≥3	137	0.5	118	86.1	96.3 ± 1.8	83.3 ± 4.0	68.1 ± 7.4	114	83.2	2.9 ± 1.6	15.2 ± 4.0	28.6 ± 7.2	1.0 ± 1.0	5.9 ± 2.6	26.0 ± 8.4

Waiting-time																
	0-11 months	1205	4.6	1034	85.8	98.1 ± 0.4	89.9 ± 1.1	77.1 ± 2.1	1014	84.1	1.9 ± 0.4	9.7 ± 1.1	20.6 ± 2.0	1.4 ± 0.4	7.0 ± 0.9	13.1 ± 1.6
	12-23 months	2908	11.1	2440	83.9	98.0 ± 0.3	88.6 ± 0.7	70.7 ± 1.6	2412	82.9	2.0 ± 0.3	10.7 ± 0.7	26.5 ± 1.5	1.4 ± 0.2	5.0 ± 0.5	10.1 ± 0.9
	≥24 months	22128	84.3	18299	82.7	95.9 ± 0.2	85.8 ± 0.3	70.9 ± 0.5	17964	81.2	4.1 ± 0.2	13.6 ± 0.3	26.8 ± 0.5	1.5 ± 0.1	5.3 ± 0.2	12.3 ± 0.4
Age period																
	16-55 years	15779	60.1	13077	82.9	97.7 ± 0.1	91.3 ± 0.3	81.8 ± 0.5	12831	81.3	2.3 ± 0.1	8.3 ± 0.3	15.8 ± 0.5	1.7 ± 0.1	6.5 ± 0.2	16.0 ± 0.5
	56-64 years	8002	30.5	6650	83.1	94.8 ± 0.3	81.5 ± 0.6	58.0 ± 1.1	6539	81.7	5.2 ± 0.3	17.7 ± 0.5	39.5 ± 1.0	1.2 ± 0.1	3.7 ± 0.3	6.4 ± 0.4

	≥65 years	2460	9.4	2046	83.2	91.5 ± 0.6	68.7 ± 1.2	37.2 ± 2.0	2020	82.1	8.5 ± 0.6	30.0 ± 1.2	60.7 ± 2.0	1.1 ± 0.2	2.7 ± 0.4	3.1 ± 0.5
Age period donor	0-15 years	529	2.0	496	93.8	97.1 ± 0.8	89.9 ± 1.5	81.5 ± 2.3	489	92.4	2.8 ± 0.8	8.9 ± 1.4	16.7 ± 2.2	1.3 ± 0.5	3.8 ± 1.0	9.2 ± 1.9
	16-55 years	16681	63.6	13737	82.4	96.9 ± 0.2	88.0 ± 0.3	73.3 ± 0.6	13547	81.2	3.0 ± 0.2	11.5 ± 0.3	24.7 ± 0.6	1.1 ± 0.1	4.6 ± 0.2	10.8 ± 0.4
	56-64 years	7296	27.8	6051	82.9	95.2 ± 0.3	84.1 ± 0.5	68.2 ± 1.0	5912	81.0	4.9 ± 0.3	15.4 ± 0.5	29.0 ± 0.9	1.9 ± 0.2	6.3 ± 0.4	15.0 ± 0.7
	≥65 years	1735	6.6	1489	85.8	93.2 ± 0.7	77.1 ± 1.3	57.2 ± 2.3	1442	83.1	6.7 ± 0.7	20.9 ± 1.3	38.0 ± 2.2	2.8 ± 0.5	9.5 ± 1.0	14.3 ± 1.3

Cold ischemia period	<10h	4540	17.3	3975	87.6	96.6 ± 0.3	87.9 ± 0.6	74.6 ± 1.2	3916	86.3	3.4 ± 0.3	11.4 ± 0.6	22.6 ± 1.1	1.0 ± 0.2	3.9 ± 0.4	11.2 ± 0.9
	10-18h	11338	43.2	10296	90.8	96.4 ± 0.2	86.9 ± 0.4	71.8 ± 0.7	10124	89.3	3.6 ± 0.2	12.8 ± 0.4	26.1 ± 0.7	1.4 ± 0.1	4.8 ± 0.2	11.2 ± 0.5
	≥18h	4398	16.8	4106	93.4	96.0 ± 0.3	85.5 ± 0.6	69.3 ± 1.1	4036	91.8	4.0 ± 0.3	13.7 ± 0.6	28.5 ± 1.0	1.7 ± 0.2	5.7 ± 0.4	11.1 ± 0.7
	Missing	5965	22.7	3396	56.9	95.4 ± 0.4	83.3 ± 0.8	67.8 ± 1.5	3314	55.6	4.6 ± 0.4	15.5 ± 0.8	28.8 ± 1.4	1.8 ± 0.2	8.4 ± 0.6	19.1 ± 1.2

Table 4: Univariate analysis of continuous variables regarding survival and competing risks between DwFG and graft loss for ETKAS patients **(A)** and multivariate analysis restricted to ETKAS **(B)** and ESP **(C)**. HR: Hazard ratio; subdist. HR: subdistribution hazard ratio; Concerning the categorical confounders of the multivariate analysis, the reported HRs and subdist. HRs refer to the second characteristic as compared to the characteristic named first.

A. Univariate analyses of variables in ETKAS data						
	Mortality		**DwFG**		**Graft loss**	
	Hazard ratio (95% Conf. int.)	p-value	Subdist. HR (95% Conf. int.)	p-value	Subdist. HR (95% Conf. int.)	p-value
Donor age [years]	1.02 (1.01 - 1.02)	<0.001	1.01 (1.01 - 1.02)	<0.001	1.02 (1.01 - 1.02)	<0.001
Recipient age [years]	1.07 (1.06 - 1.07)	<0.001	1.06 (1.06 - 1.07)	<0.001	0.96 (0.96 - 0.97)	<0.001
Cold ischemia time [hours]	1.01 (1.00 - 1.02)	0.001	1.02 (1.01 - 1.03)	<0.001	1.02 (1.01 - 1.03)	0.001

Waiting-time [years]		1.02 (1.01 - 1.03)	<0.001	1.01 (1.00 - 1.03)	0.024	0.98 (0.96 - 1.00)	0.024
B. Multivariate analysis ETKAS							
		Mortality		**DwFG**		**Graft loss**	
		Hazard ratio (95% Conf. int.)	p-value	Subdist. HR (95% Conf. int.)	p-value	Subdist. HR (95% Conf. int.)	p-value
Allocation type	standard vs. rescue	0.89 (0.78 - 1.02)	0.090	0.70 (0.60 - 0.81)	<0.001	0.98 (0.77 - 1.25)	0.885
Recipient sex	female vs. male	1.10 (1.02 - 1.19)	0.015	1.10 (1.00 - 1.21)	0.039	0.83 (0.72 - 0.95)	0.009
HLA-match	favorable vs. non-favorable	1.15 (1.03 - 1.29)	0.011	1.18 (1.03 - 1.34)	0.014	1.33 (1.09 - 1.62)	0.005
Donor age	(continuous)	1.01 (1.01 - 1.01)	<0.001	1.00 (1.00 - 1.01)	0.003	1.03 (1.02 - 1.03)	<0.001
Recipient age	(continuous)	1.06 (1.06 - 1.07)	<0.001	1.07 (1.06 - 1.07)	<0.001	0.95 (0.95 - 0.96)	<0.001
Cold ischemia	(continuous)	1.01 (1.00 - 1.02)	0.017	1.02 (1.01 - 1.03)	<0.001	1.02 (1.01 - 1.03)	0.004

time [hours]							
Waiting time [years]	(continuous)	1.06 (1.05 - 1.07)	<0.001	1.05 (1.03 - 1.06)	<0.001	0.98 (0.96 - 1.00)	0.063
Diabetes	non-diabetic vs. diabetic	1.97 (1.76 - 2.20)	<0.001	1.77 (1.55 - 2.02)	<0.001	0.60 (0.40 - 0.91)	0.017
Transplant count	1 vs. ≥ 2	1.56 (1.38 - 1.77)	<0.001	1.39 (1.19 - 1.61)	<0.001	1.32 (1.06 - 1.65)	0.014

C. Multivariate analysis ESP

		Mortality		DwFG		Graft loss	
		Hazard ratio (95% Conf. int.)	p-value	Subdist. HR (95% Conf. int.)	p-value	Subdist. HR (95% Conf. int.)	p-value
Allocation type	standard vs. rescue	0.61 (0.37 - 1.01)	0.056	0.72 (0.41 - 1.26)	0.246	0.30 (0.04 - 2.48)	0.260
Recipient sex	female vs. male	1.27 (1.06 - 1.52)	0.009	1.24 (1.01 - 1.52)	0.036	1.28 (0.57 - 2.86)	0.545
HLA-match	favorable vs. non-favorable	1.08 (0.92 - 1.26)	0.343	1.09 (0.91 - 1.30)	0.362	0.64 (0.35 - 1.19)	0.160

Donor age	(continuous)	1.01 (0.99 - 1.02)	0.418	0.99 (0.97 - 1.01)	0.457	1.09 (1.04 - 1.14)	<0.001
Recipient age	(continuous)	1.06 (1.04 - 1.09)	<0.001	1.08 (1.05 - 1.10)	<0.001	0.92 (0.84 - 1.02)	0.126
Cold ischemia time [hours]	(continuous)	1.02 (1.00 - 1.04)	0.070	1.02 (1.00 - 1.04)	0.091	1.04 (0.98 - 1.10)	0.217
Waiting time [years]	(continuous)	1.07 (1.03 - 1.12)	<0.001	1.08 (1.03 - 1.13)	<0.001	0.95 (0.80 - 1.12)	0.512
Diabetes	non-diabetic vs. diabetic	1.66 (1.35 - 2.03)	<0.001	1.49 (1.18 - 1.87)	<0.001	1.46 (0.69 - 3.10)	0.322
Transplant count	1 vs. ≥ 2	1.18 (0.87 - 1.59)	0.284	1.30 (0.93 - 1.80)	0.123	0.42 (0.12 - 1.49)	0.179

Table 5: The cumulative hazard function for survival predicted by the Cox proportional hazards model and the cumulative incidence predictions [33] for DwFG and graft loss from the competing risk model in percent for the timepoint of 5 years. For the other covariates we assumed the following values: female recipient, favorable match, recipient age of 55, waiting time of 5 years, non-diabetic, and first transplant. The models are equivalent to the ones in Table 4 but based on data from both ETKAS and ESP.

		Survival					**DwFG**					**Graft loss**				
	CIT [hours]:	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25
Allocation	**Donor age [years]:**															
Standard	10	7.6	8.0	8.4	8.8	9.2	7.4	8.2	9.1	10.0	11.1	1.0	1.1	1.2	1.3	1.4
	20	8.3	8.7	9.2	9.6	10.1	7.8	8.6	9.5	10.6	11.7	1.3	1.4	1.5	1.7	1.8
	30	9.1	9.5	10.0	10.5	11.0	8.2	9.1	10.0	11.1	12.3	1.6	1.8	2.0	2.2	2.4
	40	9.9	10.4	10.9	11.5	12.0	8.6	9.5	10.6	11.7	12.9	2.1	2.3	2.6	2.8	3.1
	50	10.9	11.4	11.9	12.5	13.1	9.1	10.0	11.1	12.3	13.5	2.8	3.0	3.3	3.7	4.0

	60	11.9	12.4	13.0	13.7	14.3	9.5	10.6	11.7	12.9	14.2	3.6	4.0	4.3	4.8	5.2
	70	13.0	13.6	14.2	14.9	15.7	10.0	11.1	12.3	13.5	14.9	4.7	5.1	5.6	6.2	6.8
	80	14.1	14.8	15.6	16.3	17.1	10.5	11.7	12.9	14.2	15.7	6.0	6.6	7.3	8.0	8.7
Rescue	10	6.7	7.0	7.4	7.7	8.1	5.1	5.7	6.3	7.0	7.7	1.0	1.1	1.2	1.3	1.4
	20	7.3	7.7	8.1	8.4	8.9	5.4	6.0	6.6	7.3	8.1	1.3	1.4	1.5	1.7	1.8
	30	8.0	8.4	8.8	9.2	9.7	5.7	6.3	7.0	7.7	8.6	1.6	1.8	2.0	2.2	2.4
	40	8.7	9.2	9.6	10.1	10.6	6.0	6.6	7.3	8.1	9.0	2.1	2.3	2.6	2.8	3.1
	50	9.5	10.0	10.5	11.0	11.5	6.3	7.0	7.7	8.6	9.5	2.8	3.0	3.3	3.7	4.0
	60	10.4	10.9	11.5	12.0	12.6	6.6	7.3	8.1	9.0	10.0	3.6	3.9	4.3	4.8	5.2
	70	11.4	11.9	12.5	13.1	13.8	7.0	7.7	8.6	9.5	10.5	4.6	5.1	5.6	6.1	6.7
	80	12.4	13.0	13.7	14.3	15.0	7.3	8.1	9.0	10.0	11.0	6.0	6.6	7.2	7.9	8.7

Figure 1:

Flowchart of selection process of transplants analyzed in this study

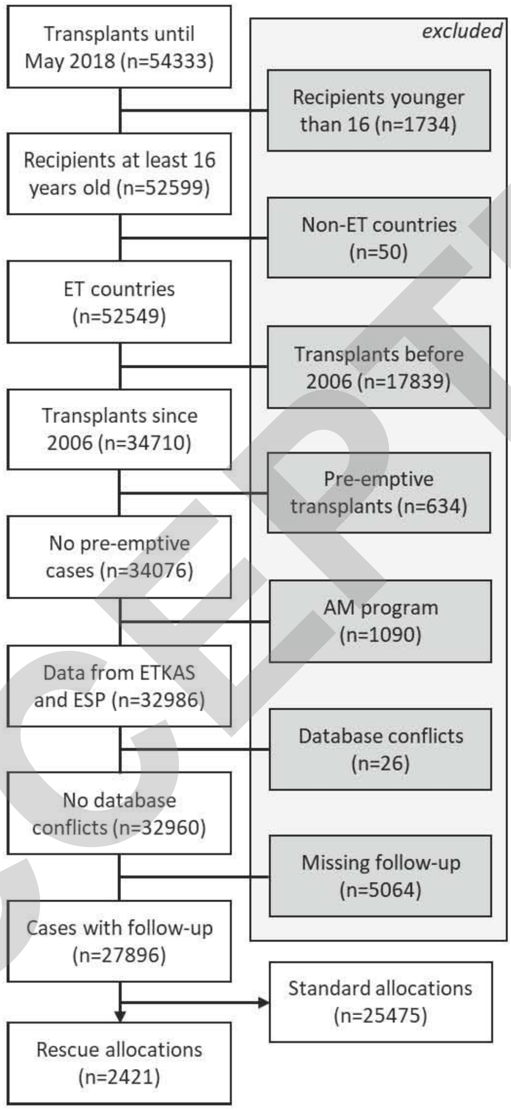

Figure 1: Flowchart of selection process of transplants analyzed in this study. Counts refer to number of transplants. ETKAS: Eurotransplant Kidney Allocation System; ESP: Eurotransplant Senior Program; AM: Acceptable Mismatch Program.

Figure 2:

Recipient age and transplant numbers for SA and RA

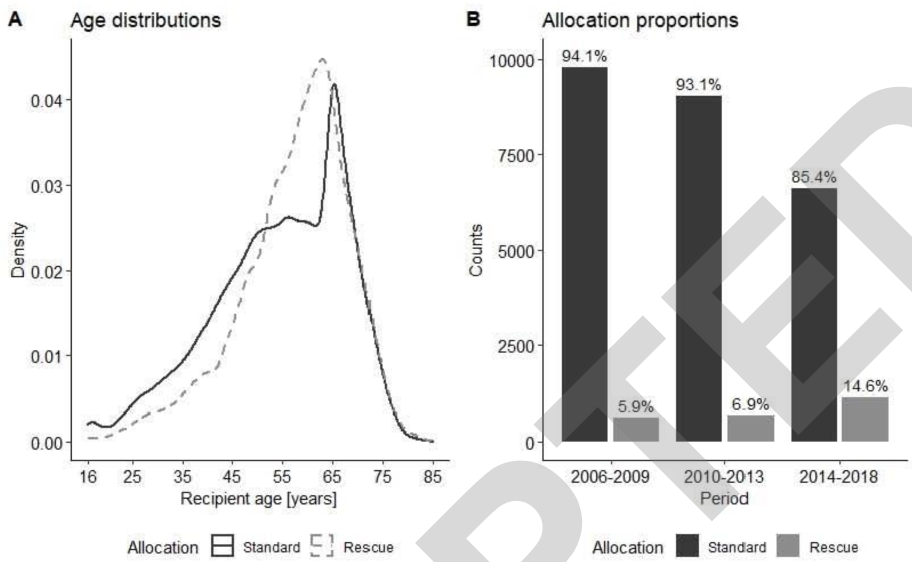

Figure 2: (A) Recipient age and **(B)** number of transplants between 2006 and 2018 with respect to allocation type. Percentages show the fraction of the respective period.

Figure 3:

Cumulative incidence curves of kidney transplantation outcome after RA vs. SA

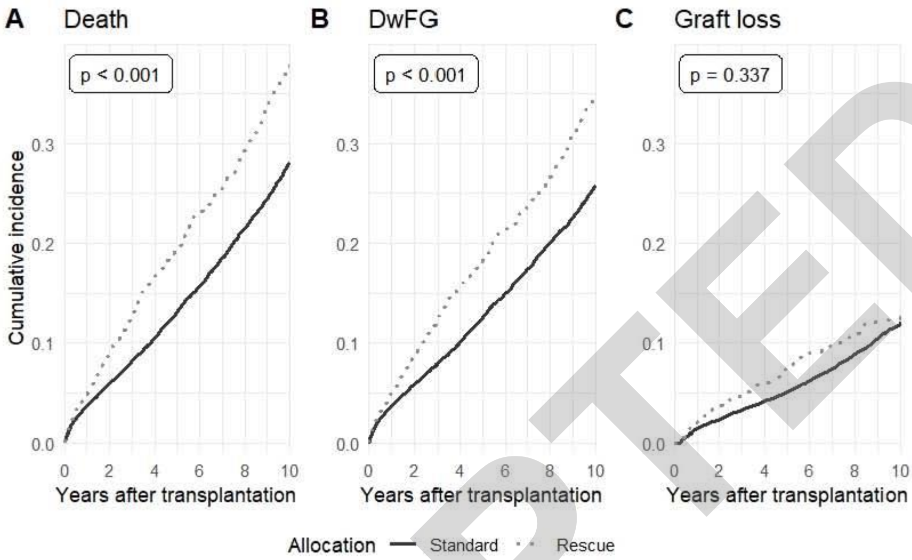

Figure 3: Cumulative incidence curves for ETKAS patients with respect to death (A), death with functioning graft (B), and graft loss (C) according to allocation.