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Editorial Comment

EDITORIAL COMMENT

To discard or not to discard: transplantation and the art of scoring

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ABSTRACT

The growing gap between inadequate supply and constantly high demand for kidney transplantation observed in the last two decades led to exploring the possibility of using organs from older donors with an increasing number of comorbidities. The main issue in this scenario is to identify transplantable organs and to allocate them to the most suitable recipients. A great number of clinical investigations proposed several acceptance/allocation criteria to reduce the discard rate of these kidneys and to improve their outcome, including histological features at the time of transplant. Despite the widespread use of several histological scoring systems, there is no consensus on their value in predicting allograft survival and there is established evidence that histological analysis is the most common reason to discard expanded criteria donor kidneys. To overcome this issue, a clinical scoring system, the Kidney Donor Profile Index (KDPI), was developed on the basis of easily accessible donor features. The KDPI score, adopted in the new US allocation procedure, has good reproducibility but presents several limitations, as suggested also in this issue of *Clinical Kidney Journal*. This observation should stimulate the search for novel scores combining clinical, histological and molecular features in an attempt to improve the decision process.

Keywords: expanded criteria donors, kidney donor profile index, kidney transplantation

The growing gap between inadequate supply and constantly high demand for kidney transplantation observed in the last two decades led to exploring novel policies to obtain more transplantable organs [1–4]. The main issue in this scenario, however, is to identify reliable criteria to recognize transplantable organs and to allocate them to the most suitable recipients [5]. In addition, the introduction of double kidney transplant to further reduce the discard rate led to a debate about the criteria for use of available grafts for this procedure [1, 6]. Finally, kidney allocation has become more and more complex because of the increasing spectrum of donors' comorbidities [1–5].

A great number of clinical investigations have roposed various acceptance and allocation principles and/or transplantation strategies to reduce the discard rate of available kidneys and to improve their outcome [6, 7]. In the attempt to predict the risk of graft failure, they included several clinical and/or histological features of donors along with recipients' characteristics.

Donor age was the first parameter suggested to negatively influence graft survival. Indeed, it is well known that the ageing kidney loses nephrons and shows a physiological reduction in glomerular filtration rate (GFR) and in its functional reserve, although the decline in renal function with age is very heterogeneous [8]. The role of donor age in determining graft outcome was confirmed by the analysis of a large transplant population showing that 3-year graft survival was 78% for donors between 20 and 24 years of age, whereas kidneys from donors >60 years

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of age had a survival rate of 58% [9]. As a second parameter, beyond age, donor comorbidities known to potentially affect renal function, including diabetes, established hypertension and death from cerebrovascular accident, have been suggested as predictors of reduced graft survival. To incorporate these parameters as a guide in decision making, the concept of the expanded criteria donor (ECD) was introduced in 2002 [10]. ECDs include all donors ≥60 years of age or those between 50 and 59 years who meet at least two of the following criteria: serum creatinine >1.5 mg/dL, a cerebrovascular accident as the cause of death or a history of hypertension [11]. In the report of the Crystal City meeting, these features were defined on the basis of a relative risk of graft failure >1.7 [11]. This initial attempt to classify donors according to the potential outcome of their kidney grafts presents important limitations in the definition of standard criteria donors (SCDs) and ECDs and is not corroborated by the results. Indeed, some kidneys labelled as SCD have a reduced allograft survival, whereas some ECD kidneys perform well. Therefore the definition criteria for ECD and SCD were not exhaustive and there was a compelling need for a systematic approach to give a more precise and graded evaluation of donor kidney quality [12].

In this perspective, several studies investigated the use of pretransplant donor biopsy (PTDB) as a tool to direct organ acceptance and allocation [1, 13, 14]. In the last 20 years, the value of PTDB findings has been hotly debated as an independent predictor of donor quality. Indeed, some observations support the hypothesis that PTDB may represent a valuable tool to identify transplantable kidneys [15, 16], whereas others demonstrate that employing histological criteria increases the risk of discarding acceptable kidneys [17]. Initially, the use of PTDB was advocated for older donors (>50 years) and those with cerebrovascular accidents, while glomerulosclerosis was considered the main informative histological lesion [18]. Several papers report non-univocal results about the importance of glomerulosclerosis in PTDB on the incidence of delayed graft function and on graft survival [13, 19]. Moreover, while there was no association between graft outcome and the percentage of glomerulosclerosis in the ECD kidneys, the rates of discard increased stepwise as the proportion of glomerulosclerosis increased above 10% [20]. These results clearly indicated that, in the absence of further studies, the percentage of glomerulosclerosis alone should not be used as the sole criterion for discarding deceased donor kidneys and/or to guide their allocation [19, 20]. Then a more extensive analysis of PTDB, including the evaluation of interstitial, tubular and vascular lesions, was considered in the attempt to predict graft outcome.

To this end, Pirani [21] suggested a composite score taking into consideration the percentage of sclerosed glomeruli and the extent of tubular atrophy, interstitial fibrosis and atherosclerosis (as indicated by the arterial wall thickness). In this score, each lesion is graded from 0 to 3 [21]. The Pirani score was then reprised by Karpinsky *et al.* [22] and Remuzzi *et al.* [1], leading to the possible definition of score values to discard or effectively allocate ECD kidneys. In particular, Karpinsky *et al.* [22], on the basis of their observation on a small cohort of transplant recipients, suggested that organs with a score ≥7 or with a score of 3 in any of the histological compartments were not suitable for transplantation, given their very poor outcome. In contrast, Remuzzi *et al.* [1], in an elegant, multicentre, matched-cohort study, evaluated the graft survival of kidneys from ECD donors used for single or dual transplant based on the PTDB score. In this study, the cut-off for single or dual transplant was set to a total score of 3. Using this approach, the authors demonstrated that the short- [23] and long-term [1] survival of kidney grafts from ECDs allocated to single or dual transplant on the basis of the histological score of the PTDB were comparable to the survival of kidneys from SCDs allocated using the routine clinical approach. In a later analysis, our group demonstrated that kidneys with a global score of 4 could be safely allocated to single transplant [14], further enlarging the use of ECD kidneys.

Despite the widespread use of pre-implantation biopsies and studies supporting the histological score in the acceptance and allocation of ECD organs, there is no consensus on their value in predicting allograft survival. In addition, there is established evidence that histological analysis continues to be the most common reason for non-acceptance of ECD kidneys [20]. Indeed, the histological approach to evaluate the quality of deceased donor kidneys presents several limitations. First is the type of biopsy to use, since wedge biopsy may overestimate the vascular and glomerular lesions compared with needle biopsy. Indeed, it is well known that the subcortical area, usually overrepresented in wedge biopsies, is characterized, particularly in aged kidneys, by increased glomerulosclerosis, inevitably causing a significant increase in the discard rate of potentially transplantable kidneys. In addition, the widely recognized interobserver variability further limits the reliability of PTDB as a tool to predict graft outcome [24–26]. Finally, as pointed out in a recent metanalysis by Wang *et al.* [27], the information available on the ability of PTDB to predict graft outcome derive from retrospective studies with several methodological limitations.

To overcome these issues, in 2009, Rao *et al.* [28] introduced the Kidney Donor Risk Index (KDRI), based on age, height, weight, ethnicity, history of hypertension and diabetes, cause of death, serum creatinine, hepatitis C status and eventual donation after circulatory death. The KDRI was established by studying a population of 69 440 adult, ABO-compatible, solitary, first-time deceased donor kidney recipients in the USA from 1995 to 2005 by a multivariable Cox proportional hazards regression model linking donor data with graft outcomes [28]. The 10 different factors are surrogates of donor quality and nephron mass. Age has the greatest impact on the KDRI, and even more so when age is >50 years. Each additional year is associated with a significant 1% additional risk of graft failure. The KDRI also increases when the donor is <18 years. Concerning height, the KDRI decreases with donor height. Weight adds to the KDRI, but only when it is <80 kg. Shorter height and lower weight are surrogate markers for a reduced renal mass [28].

This scoring system has several advantages when compared with the dichotomous definitions set by the ECD. It allows for a more precise and gradual measurement of donor quality because it is based on 10 donor factors. This index actually highlights the fact that there is wide variability in the ECD/SCD classification, with a number of SCDs having a lower estimated quality (higher KDRI) than particular ECDs. In fact, in each KDRI interval, survival is not significantly different between ECDs and SCDs, supporting the conclusion that ECD categorization does not add any valuable information on graft survival over what was already predicted by the KDRI [28]. However, the KDRI was not intended to serve as the only metric for determining donor suitability since it does not take into consideration several factors pertaining to the recipient and/or transplant procedure that may impact graft outcomes, including cold ischaemic time, human leucocyte antigen (HLA) mismatches, age/size mismatch, single versus double kidney transplant, risk of recurrence of primary disease, risk of non-compliance or the presence of donor-specific anti-HLA antibodies. Thus the KDRI should be implemented and integrated with other data.

A further evolution of the KDRI is represented by the Kidney Donor Profile Index (KDPI). The KDPI, directly derived from the KDRI, is a percentile score ranging from 0 to 100%, referring to the median donor of all transplants of the previous year [29]. A donor with a KDPI >85% presents a risk of graft failure >85% of the previous-year transplants. Donors with a KDPI of 85% were originally considered to be comparable to ECDs [29]. The KDPI score is currently the most popular allocation score in the USA, because its component variables are known and easily accessible at the time of donation and because it has good reproducibility between different centres. The Organ Procurement and Transplantation Network/United Network for Organ Sharing Kidney Transplantation Committee in 2011 completed a full review of US kidney allocation policy in an attempt to address concerns about waiting time on the priority list and the use of ECD kidneys [30]. To maximize the number of transplantable kidneys and to improve their outcome, the committee proposed donor–recipient matching based on the chances of graft and patient survival. To this end, this new system allocates the best 20% of available kidneys to younger recipients [30]. The stratification of donor quality in this programme is based on the KDPI [30]. The long-term outcomes of this recently introduced allocation system are still unknown.

However, in the last 5 years we have learned that the KDPI also presents several limitations. First, this scoring system was been developed in the USA and its use in other settings might be questionable. Recently, Lehner *et al.* [31] reported on use of the KDPI in a European cohort of patients and they concluded that it may represent a potentially useful tool for donor quality assessment in a setting different from the one in which it was developed.

The second drawback was clearly indicated by Ruggenenti and Remuzzi [32]. Any midsized Caucasian donor >63 years of age without any known comorbidities will present with a KDPI >85% [32]. In Europe, and particularly in Spain, 32.4% of donors in 2015 were ≥70 years of age and only 46.8% were <60 years [33], whereas in the USA only 5% of donors whose kidneys were transplanted in 2014 were >65 years of age [34]. Because of this high percentage of older donors, the KDPI of Spanish donors can be estimated to be >80% in more than half and close to 100% in >30%. This same observation has been recently confirmed by Lehner *et al.* [31]. They report that in their cohort the median KDPI was 66%, with a significantly higher incidence of >85% KDPI donors compared with the US population (32.3% versus 9.2%). This clear increase in the number of donors potentially classified as ECD might lead to a significant increase in the discard rate. Indeed, Bae *et al.* [35], in a national study, report that the discard rates in the entire transplant population remained high when comparing the pre- and post-KDPI eras, whereas there was a clear increase in the discard rate of discordant SCD organs with a KDPI >85%.

KDPI labelling can, indeed, induce problems in communications with patients since, by definition, a kidney with a KDPI >85% is described to a patient as 'worse than 85% of offered kidneys'. However, there is a different way to approach it, based on several recent observations. Massie *et al.* [36] showed that transplanting kidneys with a KDPI score of 91–100 reduces the risk of mortality compared with remaining on dialysis and on the waiting list in the hope of receiving a lower KDPI kidney. In addition, Jay *et al.* [37] reported that transplantation of recipients >60 years of age using kidneys with a KDPI >85% is associated with lower mortality risk after the first year compared with remaining in the waitlist. These data clearly suggest that further consideration should be given to increased utilization of high KDPI grafts in older patients in an attempt to avoid or limit time on dialysis, which remains the worse risk factor for overall mortality.

Finally, there are several concerns about the ability of KDPI to predict transplant outcome. Indeed, as suggested by different observations, the recipient's features as well as the characteristics of the transplant procedure, which are not considered in the KDRI/KDPI systems, may significantly impact graft function and survival [38]. In the present issue of the *ckj*, Sexton *et al.* [39], in a retrospective study based on Irish National Kidney Transplant Service Registry data, demonstrated that while the KDRI/KDPI is predictive of estimated GFR (eGFR) over the follow-up, it did not provide any additive discrimination above donor age alone in terms of graft failure prediction. This observation raises serious concern about the utility of a clinical scoring system in the complex process leading to organ discard or allocation, supporting an old hypothesis that donor age is the main information we need to make any significant clinical decision.

Several observations support the idea of pulling together clinical and histological information. Anglicheau *et al.* [40], in a retrospective series of 191 donor/recipient pairs, found that associating PTDB glomerulosclerosis with donor creatinine and a history of hypertension significantly improved the predictive ability for low estimated creatinine clearance at 1 year. A recent single-centre study using PTDB and the KDPI to allocate high-KDPI organs [41] showed a lower discard rate (19.8%) for the highest KDPI group (KDPI >85%) kidneys when allocated on the basis of the histological score and did not show lower graft or patient survival, as previously described by other studies [42–44]. Similar results were reported in an Italian multicentre study [45]. In this retrospective investigation, Gandolfini *et al.* [45] demonstrated that PTDB-based allocation of high-KDPI grafts led to a limited discard rate of 15% for kidneys with a KDPI of 80–90 and 37% for kidneys with a KDPI of 91–100. Although 1-year eGFRs were significantly lower in recipients of high-KDPI kidneys, graft survival was similar between kidney transplants from low- and high-KDPI donors [45]. Finally, after studying retrospectively >500 donor/recipient pairs, the Leuven group designed a novel scoring algorithm including donor age and PTDB features, in particular glomerulosclerosis and interstitial fibrosis/tubular atrophy. The Leuven score performs satisfactorily according to receiver operating characteristics curve analysis, with an area under the curve of 0.81 for 5-year allograft loss [46]. Indeed, a Leuven donor risk score >47 has 85% specificity and 81% sensitivity for graft failure within the first 5 years after transplantation [46].

Clinical and PTDB donor features are not the only data available to judge the quality of kidneys, and the introduction of reperfusion machines provides valuable information [47]. In this regard, Parikh *et al.* [48] recently suggested that perfusate biomarkers, including kidney injury molecule-1 and neutrophil gelatinase-associated lipocalin, and pump parameters of perfusion machines associate significantly with the incidence of delayed graft function and with 6-month eGFR. In contrast, Doshi *et al.* [49] suggested that current tools to evaluate some viable discarded kidneys with a KDPI ≥80, such as PTDB and/or perfusate biomarkers from a renal perfusion machine, are not sufficiently accurate to assess ECDs.

In conclusion, in this time of organ shortage, thoughtful allocation of donor kidneys is absolutely needed. The KDPI system provides the clinician with a guide to objectively assess the quality of the increasing number of ECDs. The KDPI is an easily applicable scoring system that provides a uniform platform to initiate and compare clinical studies. However, we need to

realize that the KDPI does not account for any recipient or donor/recipient parameters. At the same time, the clinical utility of performing a PTDB has not been clearly demonstrated. Thus we believe it is the time to optimize the use of ECD kidneys, combining the KDPI score and PTDB features, including molecular phenotyping, in an attempt to improve the decision process by avoiding a high discard rate and ensuring long-term graft survival. We expect more studies to be published in the near future to validate these scoring systems prospectively in large transplant populations.

CONFLICT OF INTEREST STATEMENT

None declared.

REFERENCES

1. Remuzzi G, Cravedi P, Perna A *et al*. Long-term outcome of renal transplantation from older donors. *N Engl J Med* 2006; 354: 343–351
2. Merion RM, Ashby VB, Wolfe RA *et al*. Deceased-donor characteristics and the survival benefit of kidney transplantation. *JAMA* 2005; 294: 2726–2733
3. Alexander JW, Vaughn WK. The use of ''marginal'' donors for organ transplantation. The influence of donor age on outcome. *Transplantation* 1991; 51: 135–148
4. Ojo A, Luan F, Sung RS *et al*. The use of expanded criteria donor organs for transplantation. *Transplant Rev* 2006; 20: 41–55
5. Stallone G, Grandaliano G. It is the time to rethink the criteria to define transplantable kidneys. Should we combine histological and clinical evaluation? *Transpl Int* 2017; 30: 969–971
6. Tanriover B, Mohan S, Cohen DJ *et al*. Kidneys at higher risk of discard: expanding the role of dual kidney transplantation. *Am J Transplant* 2014; 14: 404–416
7. Tso PL. Access to renal transplantation for the elderly in the face of new allocation policy: a review of contemporary perspectives on "older" issues. *Transplant Rev* 2014; 28: 6–19
8. Epstein M. Aging and the kidney. *J Am Soc Nephrol* 1996; 7: 1106–1122
9. Chertow GM, Milford EL, Mackenzie HS *et al*. Antigen-independent determinants of cadaveric kidney transplant failure. *JAMA* 1996; 276: 1732–1736
10. Port FK, Bragg-Gresham JL, Metzger RA *et al*. Donor characteristics associated with reduced graft survival: an approach to expanding the pool of kidney donors. *Transplantation* 2002; 74: 1281–1286
11. Rosengard BR, Feng S, Alfrey EJ *et al*. Report of the Crystal City meeting to maximize the use of organs recovered from the cadaver donor *Am J Transplant* 2002; 2: 701–711
12. Maggiore U, Cravedi P. The marginal kidney donor. *Curr Opin Organ Transplant* 2014; 19: 372–380
13. Pokorna E, Vitko S, Chadimova M. Proportion of glomerulosclerosis in procurement wedge renal biopsy cannot alone discriminate for acceptance of marginal donors. *Transplantation* 2000; 69: 36–49
14. Losappio V, Stallone G, Infante B *et al*. A single-center cohort study to define the role of pretransplant biopsy score in the long-term outcome of kidney transplantation. *Transplantation* 2014; 97: 934–946
15. Ruggenenti P, Perico N, Remuzzi G. Ways to boost kidney transplant viability: a real need for the best use of older donors. *Am J Transplant* 2006; 6: 2543–2553
16. Andres A, Morales JM, Herrero JC. Double versus single renal allografts from aged donors. *Transplantation* 2000; 69: 2000–2009
17. Cecka JM, Cohen B, Rosendale J *et al*. Could more effective use of kidneys recovered from older deceased donors result in more kidney transplants for older patients? *Transplantation* 2006; 81: 966–978
18. Gaber LW, Moore LW, Alloway RR *et al*. Glomerulosclerosis as a determinant of posttransplant function of older donor renal allografts. *Transplantation* 1995; 60: 334–339
19. Edwards EB, Posner MP, Maluf DG *et al*. Reasons for non-use of recovered kidneys: the effect of donor glomerulosclerosis and creatinine clearance on graft survival. *Transplantation* 2004; 77: 1411–1415
20. Sung RS, Christensen LL, Leichtman AB *et al*. Determinants of discard of expanded criteria donor kidneys: impact of biopsy and machine perfusion. *Am J Transplant* 2008; 8: 783–792
21. Pirani CL. Evaluation of kidney biopsy specimens. In: Tisher CC, Brenner BM (eds). *Renal Pathology, with Clinical and Functional Correlations*. Philadelphia: Lippincott, 1994, 85–102
22. Karpinski J, Lajoie G, Cattran D *et al*. Outcome of kidney transplantation from high-risk donors is determined by both structure and function. *Transplantation* 1999; 67: 1162–1167
23. Remuzzi G, Grinyo J, Ruggenenti P *et al*. Early experience with dual kidney transplantation in adults using expanded donor criteria. *J Am Soc Nephrol* 1999; 10: 2591–2603
24. Azancot MA, Moreso F, Salcedo M *et al*. The reproducibility and predictive value on outcome of renal biopsies from expanded criteria donors. *Kidney Int* 2014; 85: 1161–1170
25. El-Husseini A, Sabry A, Zahran A *et al*. Can donor implantation renal biopsy predict long-term renal allograft outcome? *Am J Nephrol* 2007; 27: 144–151
26. Sagasta A, Sánchez-Escuredo A, Oppenheimer F *et al*. Pre-implantation analysis of kidney biopsies from expanded criteria donors: testing the accuracy of frozen section technique and the adequacy of their assessment by on-call pathologists. *Transpl Int* 2016; 29: 234–245
27. Wang CJ, Wetmore JB, Crary GS *et al*. The donor kidney biopsy and its implication in predicting graft outcomes: a systematic review. *Am J Transplant* 2015; 15: 1903–1914
28. Rao PS, Schaubel DE, Guidinger MK *et al*. A comprehensive risk quantification score for deceased donor kidneys: the kidney donor risk index. *Transplantation* 2009; 88: 231–243
29. Pérez-Sáez MJ, Montero N, Redondo-Pachón D *et al*. Strategies for an expanded use of kidneys from elderly donors. *Transplantation* 2017; 101: 727–745
30. Leichtman AB, Mc Cullough AP, Wolfe RA. Improving the allocation system for deceased-donor kidneys. *N Engl J Med* 2011; 364: 1287–1292
31. Lehner LJ, Kleinsteuber A, Halleck F *et al*. Assessment of the Kidney Donor Profile Index in a European cohort. *Nephrol Dial Transplant* 2018; 33: 1465–1472
32. Ruggenenti P, Remuzzi G. Invited letter in response to: "Is the kidney donor profile index (KDPI) universal or UNOS-specific?" *Am J Transplant* 2018; 18: 1033–1034
33. Del Moral Martín RMG, Retamero Díaz JA, Cava Molina M *et al*. Validation of KDRI/KDPI for the selection of expanded criteria kidney donors. *Nefrologia* 2018; 38: 297–303
34. Snyder JJ, Salkowski N, Wey A *et al*. Effects of high-risk kidneys on scientific registry of transplant recipients program quality reports. *Am J Transplant* 2016; 16: 2646–2653

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35. Bae S, Massie AB, Luo X *et al*. Changes in discard rate after the introduction of the Kidney Donor Profile Index (KDPI). *Am J Transplant* 2016; 16: 2202–2207
36. Massie AB, Luo X, Chow EKH *et al*. Survival benefit of primary deceased donor transplantation with high-KDPI kidneys. *Am J Transp* 2014; 14: 2310–2317
37. Jay CL, Washburn K, Dean PG *et al*. Survival benefit in older patients associated with earlier transplant with high KDPI kidneys. *Transplantation* 2016; 101: 867–879
38. Bae S, Massie AB, Thomas AG *et al*. Who can tolerate a marginal kidney? Predicting survival after deceased donor kidney transplant by donor-recipient combination. *Am J Transplant* 2019; 19: 425–433
39. Sexton D, O'Kelly P, Kennedy C *et al*. Assessing the discrimination of the Kidney Donor Risk Index (KDRI)/Kidney Donor Profile Index (KDPI) scores for allograft failure and eGFR in Irelands National Kidney Transplant Program. *Clin Kidney J* 2019; 12: 569–573
40. Anglicheau D, Loupy A, Lefaucheur C *et al*. A simple clinico-histopathological composite scoring system is highly predictive of graft outcomes in marginal donors. *Am J Transplant* 2008; 8: 2325–2334
41. Sánchez-Escuredo A, Sagasta A, Revuelta I *et al*. Histopathological evaluation of pretransplant donor biopsies in expanded criteria donors with high kidney donor profile index: a retrospective observational cohort study. *Transpl Int* 2017; 10: 975–986
42. Carta P, Zanazzi M, Caroti L *et al*. Impact of the pre-transplant histological score on 3-year graft outcomes of kidneys from marginal donors: a single centre study. *Nephrol Dial Transplant* 2013; 28: 2637–2648
43. Navarro MD, López-Andréu M, Rodríguez-Benot A *et al*. Significance of preimplantation analysis of kidney biopsies from expanded criteria donors in long-term outcome. *Transplantation* 2011; 91: 432–441
44. Mazzucco G, Magnani C, Fortunato M *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: 3401–3409
45. Gandolfini I, Buzio C, Zanelli P *et al*. The Kidney Donor Profile Index (KDPI) of marginal donors allocated by standardized pre-transplant donor biopsy assessment: distribution and association with graft outcomes. *Am J Transplant* 2014; 14: 2515–2525
46. De Vusser K, Lerut E, Kuypers D *et al*. The predictive value of kidney allograft baseline biopsies for long-term graft survival. *J Am Soc Nephrol* 2013; 24: 1913–1923
47. De Deken J, Kocabayoglu P, Moers C. Hypothermic machine perfusion in kidney transplantation. *Curr Opin Organ Transplant* 2016; 21: 294–300
48. Parikh CR, Hall IE, Bhangoo RS *et al*. Associations of perfusate biomarkers and pump parameters with delayed graft function and deceased donor kidneys allograft function. *Am J Transplant* 2016; 16: 1526–1539
49. Doshi MD, Reese PP, Hall IE. Utility of applying quality assessment tools for kidneys with KDPI $\geq$80. *Transplantation* 2017; 6: 1125–1133