REVIEW

Organ utilization – the next hurdle in transplantation?

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SUMMARY

Nonutilization of organs from consented deceased donors remains a significant factor in limiting patient access to transplantation. Critical to reducing waste is a clear understanding of why organs are not used: accurate metrics are essential to identify the extent and causes of waste but use of these measures as targets or comparators between units/jurisdictions must be done with caution as focus on any one measure may result in unintended adverse consequences. Comparison between centres or countries may be misleading because of variation in definitions, patient or graft characteristics. Two of the most challenging areas to improve appropriate deceased donor organ utilization are appetite for risk and lack of validated tools to help identify an organ that will function appropriately. Currently, the implanting surgeon is widely considered to be accountable for the use of a donated organ so guidelines must be clear to allow and support sensible decisions and recognition that graft failure or inadvertent disease transmission are not necessarily attributable to poor decision-making. Accepting an organ involves balancing risk and benefit for the potential recipient. Novel technologies such as machine perfusion may allow for more robust guidance as to the functioning of the organ.

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Introduction

Despite the increase in deceased organ donors seen in many countries, up to 1 in 8 candidates die awaiting a heart, liver or lung transplant. In this review, we discuss how organ utilization might be measured, the benefits and pitfalls inherent in this process and possible approaches to improve utilization. The term "organ utilization" is poorly defined in the transplant literature, and there is no widely accepted definition. This is partly because the definition varies with the perspective of the user. Intensivists focus more on increasing consent rates and donor numbers, while transplant clinicians place more emphasis on the implantation of organs from consented deceased donors.

The donation-transplantation pathway has to be efficient: from identification of the potential donor, to obtaining consent, to managing the donor until retrieval, how organs are offered, accepted, retrieved, transported and transplanted. Improved approaches to requesting and better donor management will increase the number of transplantable organs [1]. Reasons why consented donors do not proceed to transplantation include the donor's family withdrew consent, refusal by the Coroner, organs deemed medically unsuitable by recipient centres or after surgical inspection, logistic

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reasons, positive virology, risk behaviour or the family placed conditions on donation [2,3].

We believe that it is important that organ utilization is measured ("if you can't measure it, you can't improve it") but the key is choosing and applying appropriate metrics. Goodhart's law states that "When a measure becomes a target, it ceases to be a good measure" as people will redirect efforts to meet the targets at the expense of other important outcomes [4], so measures should not become targets.

Definitions of donors vary between countries (Table 1) [2,5–7] so comparison between countries should be done with caution. Post-transplant outcomes are used to compare centres and to identify possible poor performance [8] but no one outcome is ideal. Different endpoints give rise to different conclusions, as shown by these three exemplars. Comparison of two liver transplant units found that one-year survival from registration was 74% and 82%, whereas one-year survival from transplantation was 98% and 92%, respectively [8]. Comparison of outcomes in three liver units found 90-day mortality rates after transplantation were 13.7% in Hannover, 12.1% in Kiel and 8.3% in Birmingham, but the calculated 90-day survival benefit of transplantation was 6.8%, 7.8% and 2.8%, respectively [9]. Use of lungs from donors who have smoked tobacco showed that, although three-year survival rates after transplantation were slightly inferior when compared with use of lungs from those without a history of tobacco use, overall survival from registration was significantly greater in those who accepted lungs from smokers [10].

Organ utilization

Most organ donors do donate

Most actual donors do become utilized donors (median 95% in European countries) although the proportion varies between 85% and 100% [11]. The proportion of transplanted organs differs between countries. The number of transplanted organs per eligible deceased donor ranges from 1.5 to 3.42 (average 2.64) [11]. Some of this variance may be explained by the differences in the demographics of the donors, such as the proportion of donation after brain death (DBD) to donation after circulatory death (DCD) donors, age, body mass index (BMI) and co-morbidities. There is a weak but negative correlation between the number of deceased donors and both actual donors ($r = -0.53$) and organs transplanted per donor (r: -0.52; Fig. 1) suggesting increasing the number of deceased donors does not translate into an equivalent increase in organ transplants.

Table 1. Classification of deceased organ donors.

Definitions of deceased donors*
Eligible donor: a donor who meets nationally agreed criteria for organ donation
Consented donor: an eligible potential donor with consent for organ donation to take place
Utilised donor: a consented donor where at least one organ has been retrieved with the intention of transplantation
Actual donor: a utilised donor where at least one organ has been implanted in a patient

UK: NHSBT defines eligible donors after brain death (DBD) are as patients for whom death was confirmed following neurological tests and who had no absolute medical contraindications to solid organ donation. Eligible donors after circulatory death (DCD) are defined as patients who had treatment withdrawn, and death was anticipated within four hours, with no absolute medical contraindications to solid organ donation. Absolute medical contraindications include age >85 years (on or after their 85th birthday) and certain infections and malignancies. United States: The OPTN defines eligible death for reporting purposes of DSA performance assessments. An eligible death for deceased organ donation is defined as the death of a patient who meets all the following characteristics: is 75 years old or less; is legally declared dead by neurologic criteria according to the current standards of accepted medical practice and state or local law; has body weight of 5 kg or greater; has a body mass index (BMI) of 50 kg/m^2 or less; and has at least one kidney, liver, heart or lung that is deemed to meet the eligible data definition and no medical contraindications for transplant.

*Eurotransplant: defines a reported donor as a person for whom consent has been given for organ donation and that is reported to the Eurotransplant duty desk and an actual donor as a consented eligible donor in whom an operative incision was made with the intent of organ procurement for the purpose of transplantation and from whom at least one organ was procured for the purpose of transplantation https://www.eurotransplant.org/wp-content/uploads/2020/01/H9-The-Donor-February-2020.pdf.

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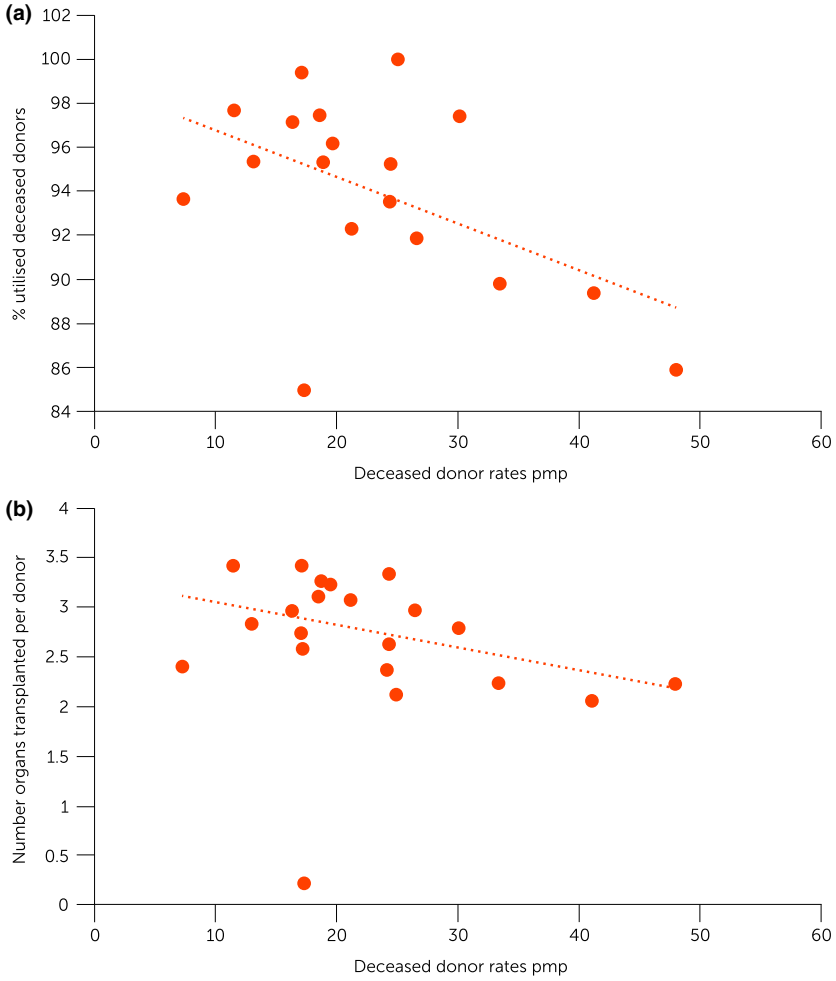

Figure 1 Deceased donor rates per million population and percentage of utilized donors (a) and number of organs transplanted per million population (pmp) (b). Figures are taken from Council of Europe [11] and show data from those countries with >100 donors/year.

Decline of organs may adversely affect transplant candidate survival

Lai *et al.* [12] found that most candidates for LT who died or were removed from the list had received one or more offers of a liver, and over half received one or more offers of a high-quality liver. Two-thirds of the declines were attributed to concerns regarding donor quality. Similar conclusions were reported by Hsu in an analysis of nearly 4000 paediatric liver transplant candidates: of livers that were successfully transplanted into children, 53% were initially refused for another child. Of those children who died or were delisted, 55% received an offer of one or more liver that was subsequently transplanted successfully into another recipient [13]. Volk *et al.* [14] developed models that predicted the gain or loss of life by accepting a given liver compared with waiting for the next offer. Among organ offers, even when estimated gain in survival was greater than one year, the offer was accepted only 10% of the time. Comparable conclusions were reached for kidney offers [15].

Variation in practice between units does impact on wait-list mortality: Mitchell *et al.* [16] concluded that centre-level acceptance rates were associated with wait-list mortality, with a >10% increase in the risk of wait-list mortality for every 1% decrease in a centre's adjusted liver offer acceptance rate. In an analysis of declined offers in the UK of deceased donor kidneys that were subsequently transplanted, patients listed at centres with higher decline rates had longer waiting times but there was no impact on 1-year graft function [17]. A retrospective analysis of 206 livers that were declined by a median of 4 other UK centres showed that no adverse impact on three-year graft survival or primary nonfunction even though half the declines were because of donor quality [18]. Comparable findings are

seen with other organs [19,20]. Benchmarking may be a useful approach to comparison between centres [21] although different donor and recipient demographics may make comparison a challenge [22,23].

Nonretrieval or nonutilization?

Organs may be declined before retrieval, at retrieval or after retrieval following assessment in the transplanting unit. Financial and other incentives that drive high retrieval rates may be associated with lower implantation rates. Yu analysed [24] all deceased donors in the United States between 2000 and 2018, where at least one solid organ was recovered and found that about 1144 kidneys per year were not retrieved. Although these donors had overall lower quality kidneys, there was substantial overlap in quality between nonprocured and procured kidneys. Nearly, one-third of kidney nonprocurements were attributed to donor history, even though the donor donated other organs. Nonprocurement odds varied widely across OPTN regions, with a positive correlation between donor kidney nonprocurement and kidney discard rate at the donation service area level. Others [25,26] have noted there was considerable geographic variation in the odds of discard across the United States, which further supports the notion that factors beyond organ quality contributed to kidney discard.

Quantifying donor risk

Risk/benefit balance

Perhaps the most difficult challenge in organ transplantation is the decision whether to accept or decline an offered organ. The risks associated with the donor or organ need to be balanced against the risks of the patient dying or becoming too ill while awaiting another offer. There are many valid reasons why clinicians decline an organ from a deceased donor who meets the nationally agreed criteria for donation. All donated organs are associated with risk: the risk may be of disease transmission, non- or poor function or technical factors.

Some risks are relatively easily managed (such as the use of HCV-positive organs for noninfected recipients) whereas other risks are less easily managed and may lead to reduced graft and patient survival.

Risk of disease transmission by donor organ

Organs may be declined because of associated risk of disease transmission. Concern over those potential donors whose lifestyle poses an increased risk of bloodborne virus disease transmission such as sex workers or prisoners has led to underuse of organs from such donors [27]. Several studies have shown survival benefits of using organs from donors with increased risks of transmitting some viral infections. It is recognized that infection may occur from occult hepatitis B virus infection where HBV DNA is present in enough quantity to transmit disease but too low a level to be detected by NAT testing [28]. The advent of effective antiviral therapy for HCV has allowed greater use of organs from such donors for uninfected and suitably consented recipients [29,30]. However, not all donor-transmitted infections are as easily treated. A cohort analysis of 2602 increased infectious risk donor (IRD) cardiac allografts that were offered to 10 851 candidates found that of those who declined the offer, 58% underwent a heart transplant from a non-IRD, 12% underwent later transplant from an IRD, and 8% were removed from the wait-list because of death or decompensation. Stratified Cox-adjusted estimates of survival at one year from the initial offer were 92% for those who accepted and 83% for those who declined, a benefit that persisted through five years postoffer [31]. Comparable conclusions were reached by Bowring [32] who concluded that accepting an IRD kidney was associated with substantial long-term survival benefit.

Other studies have shown that suitable organs from many donors who might transmit malignancy or infection are not used [33,34] as are other potential donors who died from, for example, asphyxiation or drowning [35–38]. That fear of risk of disease transmission affects patient survival is amply demonstrated by the fact that many organs with a risk of transmission of cancer of less than 1% are declined by recipients who have a risk of death without a transplant in excess of 10% [34,35].

Organ assessment is difficult

For most solid organs, there are models that help predict the functioning of the organ after transplantation and, if combined with donor and logistic factors, can help the surgeon and recipient decide whether to use an offered organ.

Organ quality can be assessed in a variety of ways: for kidneys, for example, suitability can be assessed visually using criteria such as anatomy and aberrant structures, tumours and perfusion rates, or using renal histology using scores such as the Banff Score, the Pirani–Remuzzi Score or Maryland Aggregate Pathology Index (MAPI). Others have used clinical scores such as

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the KDRI and iBox. For kidneys that are placed on machine perfusion, other parameters can be assessed including vascular resistance, function (such as urine flow) or measurement of various biomarkers. Renal histology may be helpful in determining whether to implant neither, one or both kidneys into the recipient although use of biopsies in deceased donor kidney to guide organ utilization is controversial [39–43].

For livers, there are several models predicting patient or graft survival, these include MELD, donor age × recipient MELD (D-MELD), difference between listing MELD and MELD at transplant (Delta MELD), donor risk index (DRI), Donor Quality Index (DQI), Survival Outcomes Following Liver Transplant (SOFT), balance-of-risk (BAR), University of California Los Angeles-Futility Risk Score (UCLA-FRS), and UK-DCD score. Schlegel analysed their predictive value and concluded [44] that most prediction scores showed low positive predictive values for post-transplantation mortality, despite good specificity. Flores and Asrani [45] reviewed the DRI one decade after its introduction and concluded the DRI has served as a useful metric of donor quality and enhanced understanding of donor factors and their impact upon recipients. DRI has provided the transplant community with a common language for describing donor organ characteristics and has served as the foundation for several tools for organ risk assessment. As the authors concluded, the liver DRI is a useful tool in assessing the interactions of donor and recipient factors and their impact on post-transplant outcomes. However, limitations of statistical modelling, choice of donor factors, exclusion of unaccounted donor and geographic factors, and the changing face of the liver transplant recipient have tempered its widespread use.

Similar models are published for other organs [46–48].

While these models can help identify those factors that are statistically associated with poor graft function in large registry analyses, they have several limitations.

Applicability

Prognostic models can only be applied to the population from which they have been derived. It is simplistic to apply data derived from carefully matched donor-recipient pairs to all potential donors. Some models use just donor parameters, others donor and logistic parameters and others use donor, logistic and recipient factors. All three give important and clinically helpful information but their use in clinical practice will depend on the question being asked.

Validity of data

Models are derived from prospectively collected data: terms used must be defined, data collection complete and laboratory variation accounted for. Some variables which show strong correlation with outcome (such as liver perfusion) are subjective and hard to quantify. Subjective assessment may not correlate with objective measurement (such as with liver steatosis) [49]. Furthermore, important prognostic variables may not be adequately collected in some registries (e.g. postwithdrawal respiratory and haemodynamic parameters in Maastricht III DCD donors).

Variable endpoints

The end point of models need clear definition: some have used primary nonfunction or delayed graft function, others assess graft survival at different time points. Factors that predict short-term graft function do not necessarily predict longer term graft function. Thus, in deceased donor livers, a split liver is not associated with worse 30-day graft survival but does affect one-year graft survival, and graft steatosis affects one-year but not early survival [50].

Unstated confidence intervals and predictive ability

Many models use the *C*-statistic to assess predictive ability. A *C*-statistic of 0.5 is equivalent to tossing a coin to predict outcome, while that of 1.0 means perfect predictive ability. Many models in transplantation have only moderate ability with a *C*-statistic of 0.6–0.7 [51]. There are concerns with the use of this statistic [52,53]. Not all models and markers state the confidence intervals of their prediction. Providing data such as half-life of an organ, median or mean survival is informative in population studies but less so when applied to an individual. In 2014, Dare *et al.* [54] critically evaluated the levels of evidence for tools used to assess deceased donor kidneys. They concluded that while there was a plethora of appraisal tools, very few demonstrate desirable predictive power to be useful in clinical decision-making. In 2020, van Moos *et al.* [55] reviewed the currently available methods used to assess donor organ quality including histopathology, clinical scores and machine perfusion characteristics with special focus on molecular analyses of kidney quality and concluded that the lack of good measures of organ quality is a serious challenge in terms of acceptance and allocation of an organ.

Chronology

Prognostic models need updating and take into account changes in donor and recipient demographics and management. For the liver, Flores and Asrani [45] noted the DRI was derived from data before the MELD era but is currently being applied to expand the donor pool while concurrently meeting the demands of a dynamic allocation system. They suggested the model may benefit from being updated to provide guidance in the use of extended criteria donors by accounting for the impact of geography and unmeasured donor characteristics. DRI could be better adapted for recipients with nonalcoholic fatty liver disease by examining and including recipient factors unique to this population.

Reasons why organs are declined

There are many reasons why organs are declined (Table 2) and retrospectively determining the reason for each declined organ is, in practice, far from easy. Multiple factors are at usually at play and, for most organs, decisions to reject an organ offered will be based on more than one reason.

Uncertainty about donor/graft quality

All grafts carry risk of nonfunction or poor function (early or late) and of disease transmission. Terms such as "marginal donor" mask the differing impacts associated with that organ. The risk associated with organs is well described by several groups [56–58] and has been explored above.

Logistic factors

These are often simple to identify but remedying them may be more complex. Hospitals in most, if not all, jurisdictions are under pressure, and donation and transplantation must compete for ITU beds and operating theatre time and the time of many healthcare professionals. The recent reduction in donation and transplant activity seen during the COVID-19 pandemic is clear evidence of the competition for limited resources [59]. Ensuring that organs are not lost

Table 2. Reasons why offered organs are not accepted.

Donor-related
- Medical reasons: risk of disease transmission too high
- Social reasons: potential risk of disease transmission because of behaviour, even with negative virological tests

Organ-related
- Likely poor function (short- or long-term)
- Technical (e.g. size, anatomical variants)
- Immunological (blood group, HLA mismatch, expected positive cross-match)
- Damage (either premorbid or at retrieval or during transport)
- Tumour

Logistic issues
- Retrieval
  - Lack of theatre space or lack of an organ retrieval team
- Prolonged expected transport time
- Recipient
  - Time taken to identify suitable recipient
  - Lack of theatre access
  - Lack of surgeon/anaesthetist
  - Lack of ITU or ward bed

Recipient
- Lack of consent
- Delay getting to hospital
- Unwilling to accept that organ
- Recipient unwell or no longer meets criteria for transplantation
- Positive cross-match

Appetite for risk
- Surgeon
- Clinical or managerial team
- Recipient

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because of shortage of facilities and human resources is the responsibility of healthcare managers and those who have the challenging role of allocation of resources. The importance of logistic factors is supported by the observation in the United States that more kidneys are discarded at weekends and those that are discarded are of higher quality as assessed by the KDPI [25].

Availability of healthcare professionals

The physical and mental demands of being a transplant surgeon are a challenge that is likely to increase in the coming years [60–62]. As organ donation rates rise in many countries, transplant numbers are likely to increase. However, changes to donor demographics mean that more organs will likely come from elderly, co-morbid patients. This will increase the stress of making organ utilization decisions. Transplant surgery is becoming a less popular career choice, and surgeon burnout due to overwork and anti-social hours is a pressing concern in many countries [63–65].

Fear of poor outcomes and regulatory processes

Regulation and publication of outcomes is necessary and desirable in clinical medicine and transplantation is no exception. However, inappropriate use of outcome measures does have an impact on organ utilization [8,66,67] and may inhibit innovation [68]. Snyder [69] examined the perception that transplanting high-risk kidneys causes programmes to be identified as underperforming and concluded there was no evidence that programmes that accept higher risk kidneys are at greater risk for low performance evaluations and risk aversion may limit access to transplant for candidates while providing no measurable benefit to programme evaluations. In our experience, regulators and commissioners are aware of the risks and unintended consequences of monitoring and comparisons [70] and the issue lies more with the fear of sanction rather than the reality, although this varies greatly between countries.

Opportunities for improving organ utilization

Sharing and learning from others

Although comparison between different countries is a challenge [71–78], it is important that clinicians continue to share experiences and learn from both success and also failure. But for this to occur, there needs to be common terminology and an effective and funded international registry.

Resolving logistic issues

As indicated above, organs may be declined for logistic reasons (such as lack of beds, operating time, skilled healthcare practitioners). Correction of these issues is important but is challenging when overall healthcare resources are limited.

Supporting the recipient

Understanding of risk is complex [79,80] and limited patient understanding may affect the decision to accept higher risk organs [81,82]. Time spent in presentation of risk is often helpful [83] although technologies such as a mobile app or other web-based approaches may not translate into greater acceptance of IRD organs [84,85]. Of course, the potential recipient has the right to agree or disagree whether to accept an organ and most patients want to be involved in that decision [86]. In the UK, it is recommended that potential recipients are asked prior to activation on the list if they wish to have all organ offers discussed with them or not. If so, this wish should be accommodated, provided there is enough local resource to comply with this request and if the time needed for the discussion and possible decline of the organ does not significantly adversely impact on the quality of the organ if subsequently offered to other patients [87].

Most organs are refused on behalf of the patient by the implanting surgeon (often after peer discussion). Involving patients in this decision-making process is clearly desirable and is preferred by many patients [88] but not only poses logistic challenges in a time- and resource-limited situation but also assumes a good level of understanding of complex issues made in a challenging situation and a high degree of health literacy and education and understanding of complex medical language. Those with a higher level of education may be more likely to decline an IRD organ [89]. While it is possible for vulnerable patients to delegate the patient advocacy to another, this adds a further degree of complexity [90]. While discussions with the intended recipient may not be feasible in all cases, informing the patient after the offer has been declined on their behalf has been suggested to reduce inappropriate declines [91]. However, most of the studies have been relatively small and how far extrapolation of findings derived in a

theoretical situation can be extrapolated into the real-time situation remains uncertain.

Supporting the surgeon

Decisions to use or reject organs are often made at night and with limited information about the potential deceased donor. The implanting surgeon is accountable for the decision: the perceived penalties of accepting an organ that may not function or transmits disease often seem greater than declining the offer. The occasional story of recipient death from donor-transmitted disease also puts severe pressure on the transplanting surgeon [92]. Early deaths after transplantation are usually rigorously investigated at a local level but deaths awaiting a graft are more readily accepted as being a result of the organ shortage. An adverse outcome is not necessarily an indicator that the decision was wrong. Indeed, it might be argued that if a unit has no cases of graft loss or patient harm from donor disease transmission, the unit is too cautious in its approach.

Shared decision-making with the potential recipient at the time of the offer, as outlined above, may be expected to support the surgeon by sharing responsibility for the decision but concerns would still remain over whether the patients had given fully informed consent. This is especially challenging given the limited amount of time that implanting centres are given to make a decision on whether to accept or decline a deceased donor organ offer (currently 45 min in the UK) and that decisions usually have to be made at night. There appears a wide spectrum of views and practice [93].

Many transplant units have policies where organ offers are discussed with other colleagues. Although the authors are aware of anecdotal evidence that this may lead to improved organ utilization, the success (or failure) of these approaches is very much dependent on the overall risk appetite of the unit. It may be that wider consultation leads to a higher offer decline rate due to dilution of clinical responsibility and a form of "regression towards the mean".

Improved organ offering systems

Organ offering algorithms should more accurately and realistically match offered organs and potential recipients [94,95]. Offering systems should identify those organs at high risk of discard and ensure offering to those recipients who might accept them [95].

Improved donor management

Improved and protocolized donor management may result in improved use of organs [96]. National guidelines are based largely on consensus rather than evidence [97]. Protocol-based critical care has the potential to increase the quantity and improve the quality of organs available for transplantation [98,99]. Assessment of novel procedures is associated with legal, ethical and logistic challenges [100–102] so relatively few such studies have been done. Facilitating ethical studies would allow testing of new interventions leading to greater organ use.

Use of novel machine perfusion technologies

Organ preservation and re-conditioning using machine perfusion technologies continue to generate promising results in terms of viability assessment, organ utilization and improved initial graft function [103,104]. Both hypothermic and normothermic machine perfusion have been used to assess and resuscitate organs that would otherwise have been discarded. Clinical studies suggest that machine perfusion will offer real benefits when compared with conventional cold preservation for kidneys and livers. Use of machine perfusion has been effective in the resuscitation and assessment of livers allowing the successful transplantation of livers that would otherwise have been discarded [105,106]. While more work is required to agree endpoints to define those organs which can be safely used, these studies show the potential benefit of such approaches to increase organ utilization. Likewise, kidney utilization may be improved by machine perfusion [107]. Lung transplantation may be improved by increasing use of conditioning and indeed conditioning centres have been shown to have some benefit in improving organ utilization [108,109]. Re-conditioning may also increase the number of hearts that can be safely transplanted: a recent health technology assessment reported that based on very low quality of evidence, the outcomes for recipients of DCD hearts preserved using a portable normothermic cardiac perfusion system appear to be similar to outcomes for recipients of hearts from donors after neurological declaration of death [110].

Increasing use of offered organs

Identifying those characteristics of organs that do not function is based on observations from organs that were

transplanted. It is likely that some organs that have been discarded could be safely and appropriately used in carefully selected recipients [111]. It is clear that there is significant variation in practice, and this is largely due to the difficulties in making the right decision.

Providing clear guidance as to what is an acceptable risk will help the accepting surgeon make a rapid and appropriate decision. As discussed above, current models lack sufficient precision when applied to the individual recipient. The potential to evaluate organ function on *ex situ* perfusion devices may provide greater certainty about the appropriate use of the organ [112].

Accountability and responsibility

In many jurisdictions, the implanting surgeon is accountable for any failures in care [113–115]. Anecdotal evidence suggests surgeons may decline organs because of fear of subsequent litigation if an implanted organ has an adverse outcome. One solution is that the surgeon should utilize organs where the donor and organs meet previously agreed and, where possible, validated criteria, regardless of surgical opinion. This would remove accountability from the surgeon, but, in reality, surgeons are most unlikely to use organs that they deem unsuitable and would rightly regard such practice as unethical. In practice, there is often a detailed discussion between the surgeon, physician and potential recipient to decide whether a donated organ should be accepted. Evidence of a discussion between skilled healthcare practitioners and patients will usually go some way towards protecting the surgeon from accusations of malpractice when the graft fails or transmits a disease. So, while the surgeon may be the accountable individual in the eyes of the law, actual clinical responsibility lies with the transplant team. Other (and much more controversial) approaches would be to hold surgeons more accountable for declining organs or to question those centres with a very low rate of nonfunction. Publishing decline rates is already done by several organizations, usually at a centre-level, and may support increased organ utilization [89]. It could be argued that a unit that has no early graft failures may be declining too many organs. Similar arguments have been put forward for appendicitis where higher rates of surgery for noninflamed appendix may be justified by lower complication rates in those who did have appendicitis [116]. However, the best solution likely lies elsewhere, most probably in having better prognostic markers.

Use of organs where there is uncertainty about their function is both ethical and appropriate when there is both fully informed patient consent and appropriate oversight. A central database of those organs will, in time, lead to clearer understanding of which organs should not be used for any patient.

Conclusions

Despite most countries seeing an increase in the number of actual organ donors, some patients are being denied access to transplantation because of organ shortage. Reducing the inappropriate discard of organs will help increase access. There is no single solution to increasing the use of offered organs. It is recognized that increasing organ utilization is one of several measures that need to be considered in trying to improve outcomes for patients in need of an organ transplant. Utilization has to be appropriate so increasing utilization must not be at the expense of worse overall outcomes fr those in need. Clinicians need more support to decide whether an organ is suitable for a given recipient. Regulators, service commissioners and transplant candidates need to understand the strengths and weaknesses of metrics and appreciate that no one metric adequately allows an optimization of the donation/transplant pathway. The development of both *in* and *ex situ* perfusion and organ resuscitation may allow more organs to be safely transplanted.

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