

## ORIGINAL ARTICLE

# Pancreas utilization rates in the UK – an 11-year analysis

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## SUMMARY

Utilization of pancreases for transplantation remains inferior to that of other organs. Herein, we analysed UK pancreas discards to identify the reasons for the low utilization rates. Data on all pancreases offered first for solid organ transplantation between 1st January 2005 and 31st December 2015 were extracted from the UK Transplant Registry. The number of organs discarded, reasons and the time point of discard were analysed. A centre specific comparison was also undertaken. 7367 pancreases were offered first for solid organ transplantation. 35% were donors after circulatory death (DCD). 3668 (49.7%) organs were not retrieved. Of the 3699 pancreases retrieved, 38% were initially accepted but subsequently discarded. 2145 (29%) grafts offered were transplanted as simultaneous pancreas-kidney or solitary pancreas. 1177 (55%) were transplanted on the first offer whilst the remaining 968 were transplanted after a median of three offers. 52% DBD pancreases were accepted and transplanted on the first offer compared with 68% DCD grafts. There were significant differences in discard rates between centres (30–80% for DBD and 3–78% for DCD,  $P < 0.001$ ). A significant number of solid pancreases are discarded. Better graft assessment at retrieval could minimize unnecessary organ travel and discards. Closer links with islet programmes may allow for better utilization of discarded grafts.

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## Key words

acceptance criteria, allocation process, centers variation, pancreas clinical, pancreas discard, pancreas transplantation

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## Introduction

In the United Kingdom (UK), it is expected that by 2025 there will be five million people diagnosed with diabetes mellitus [1]. Whole organ pancreas transplantation is currently the best therapy for diabetic patients suitable for a transplant [2], despite an increased risk of perioperative morbidity and mortality following surgery. In diabetic patients with associated renal failure, a functioning simultaneous pancreas and kidney (SPK)

transplant offers a better survival compared to kidney transplantation alone [3,4] with 1- and 5-year survival rates of 89% and 79%, respectively.

The persistent discrepancy between the supply of donor pancreases and the need for transplantation is further compounded by low utilization of the available organs. Currently, in the UK, only 38.3% of donors after brain death (DBD) and 19.2% of donors after circulatory death (DCD) proceed with pancreas donation. Of these, 85.2% of the DBD pancreases are retrieved, and just

48.2% of these are transplanted. In DCD donors, the conversion rate is lower with 79.2% of pancreases retrieved, of which 46.6% are transplanted [5]. Reduced utilization of donated pancreas grafts is multifactorial, but may be explained by inconsistent assessment of donor characteristics [6], lack of predictive markers of organ function [7], low predictive value of donor risk indices [8] and technical complexity of the retrieval procedure [9]. As a result, the UK waiting list mortality for patients waiting for an SPK is approaching 30% [10].

Before 2010, donated pancreases were allocated to a centre using a zonal allocation scheme which divided the UK into equal retrieval zones, allocated to a transplant centre.

To address some of the centre variations and improve organ utilization, a new UK National Pancreas Allocation Scheme (NPAS) was introduced in December 2010. This scheme is unique in that both islet and solid organ recipients are considered for each donated pancreas. A complex algorithm allocates the organ either for solid pancreas or islet transplant [11]. Patients are prioritized according to a points system based on seven donor, recipient and transplant factors: total human leucocyte antigen (HLA) mismatch, waiting time, sensitization, travel time, body mass index (BMI), dialysis status and age. A score is calculated for every potential recipient, and the pancreas is allocated to the patient with most points. The scoring system was conceived in such a manner that pancreases from donors with a low BMI are transplanted preferentially as vascularized pancreas and high BMI pancreases are transplanted as islets [12]. During the period of the NPAS, since offers are made for a specific patient and not to a centre, one centre may be offered the organ for multiple patients if they appear on a matching run.

The UK has an established National Organ Retrieval System, whereby organs are recovered by multi-organ donor teams deployed according to distance from donating hospitals. Currently, there are 10 organ retrieval teams based in liver or pancreas transplant centres, (eight based in pancreas transplant centres) and all retrieval surgeons would have completed a competency-based training prior to certification by enrolment in a National Retrieval Masterclass. This includes online education, theoretical and hands on component as well as supervision to independent practice prior to sign-off by the regional retrieval team leads.

In recent years, in addition to an increasing use of DCD donors, the demographics of the donor population in the UK have changed significantly. Within a decade, the number of donors >60 years old increased

from 14% to 35%, whilst the prevalence of a body mass index  $\geq 30$  kg/m<sup>2</sup> almost doubled [13]. Organs from older, higher BMI and DCD donors can achieve similar outcomes with lower risk donors, provided that risk factors are not cumulative and ischaemic times are minimized [14]. Nevertheless, data suggest great variability between the UK centres in the utilization of these donors [11], but the centre and surgeon risk appetite in pancreas transplantation in the UK remains relatively unexplored [15,16].

Therefore, the aims of this study were to identify the factors associated with high organ discard rates, assess the degree of variation in the acceptance criteria among the UK centres and evaluate the impact of the introduction of the NPAS on organ utilization.

## Patients and methods

### Patient population

All pancreases offered first for solid organ transplantation between 1st January 2005 and 31st December 2015 to the eight pancreas transplant centres in the United Kingdom were included in this analysis. Data were extracted from the UK Transplant Registry and included donor type (DBD/DCD), age, gender, weight, height, girth, body mass index (BMI), blood group, cause of death, virology and past medical history (smoking status, drug abuse or cardiovascular disease). Each donated organ was offered sequentially to each centre between 1st of January 2005 and 30th of November 2010) and to named patients via the NPAS since the 1st December 2010. The first seven offers were analysed because of the volume of offering data and the small proportion that result in transplantation at the eighth offer (5%).

A retrospective analysis was undertaken focussing on the number of pancreases that were not transplanted; the reasons for discard and whether the pancreas was discarded before or after the organ was retrieved. A centre specific comparison was then undertaken to analyse and compare the discard reasons. Centres were classified by activity volume during the study period, defined as follows: low <150 (three centres), medium 150–300 (three centres) and high >300 (two centres).

### The UK pancreas offering system

Prior to 2010, the UK was divided into equal retrieval zones assigned to one of the transplant units. These were the first to be offered organs from their allocated retrieval

zone. If the pancreas was not accepted, it was then offered to the centre ranked highest based on a 'balance of exchange' which considered the number of transplanted pancreases exported/imported from each retrieval zone. Pancreases were offered for islet transplantation if not suitable for whole organ transplantation.

A NPAS was introduced in December 2010 and is unique as it is patient specific (as opposed to centre based offer) and considers solid pancreas and islet transplantation for every donated organ. If the donor BMI is  $<30 \text{ kg/m}^2$ , the organ is offered initially for solid organ transplantation whilst organs from donors with a BMI  $>30 \text{ kg/m}^2$  are offered first for islet transplantation. The donor age range also increased and is currently 8–60 years old.

In the UK, pancreases are offered prior to the start of the organ retrieval procedure. If the first centre declines, the organ is offered to the next matched patient on the list. To minimize the duration of the offering process, a fast track scheme was introduced in December 2010. This is triggered by a number of points (e.g. minimum number of centres declining the pancreas offer, the organ declined after the retrieval procedure has started etc.).

All centres perform virtual cross-match. For those recipients requiring a full cross-match, this is initiated as soon as possible before or during the retrieval.

### Statistical analysis

All statistical analyses were performed using Statistical Analysis System (SAS) Enterprise Guide software. Donor characteristics were compared according to whether the organ was transplanted or discarded. This analysis was performed separately for DBD and DCD donors. Donor age, girth and BMI were analysed as continuous factors. Past smoker status, past drug abuse, past cardiovascular disease and cause of death were analysed as categorical factors. To compare the medians for continuous factors, the Kruskal–Wallis test was used, and for categorical factors, a chi-squared test was used.

To investigate whether the introduction of the NPAS in 2010 had an effect on the utilization of retrieved pancreases, a logistic regression model was used to compare the proportion of pancreases transplanted before and after the introduction of the NPAS adjusting for donor characteristics.

For the calculation of the Pancreas Donor Risk Index (PDRI), missing values were imputed based on the distribution of the cohort using the mean for continuous variables and the largest group for categorical variables.

Unadjusted 5-year pancreas graft survival rates, by offer acceptance number, were calculated using the Kaplan–Meier method. Graft survival was censored for death whilst pancreas graft failure was defined as the day of return to permanent insulin dependence. Twenty-eight cases were excluded from the survival analysis because of missing data.

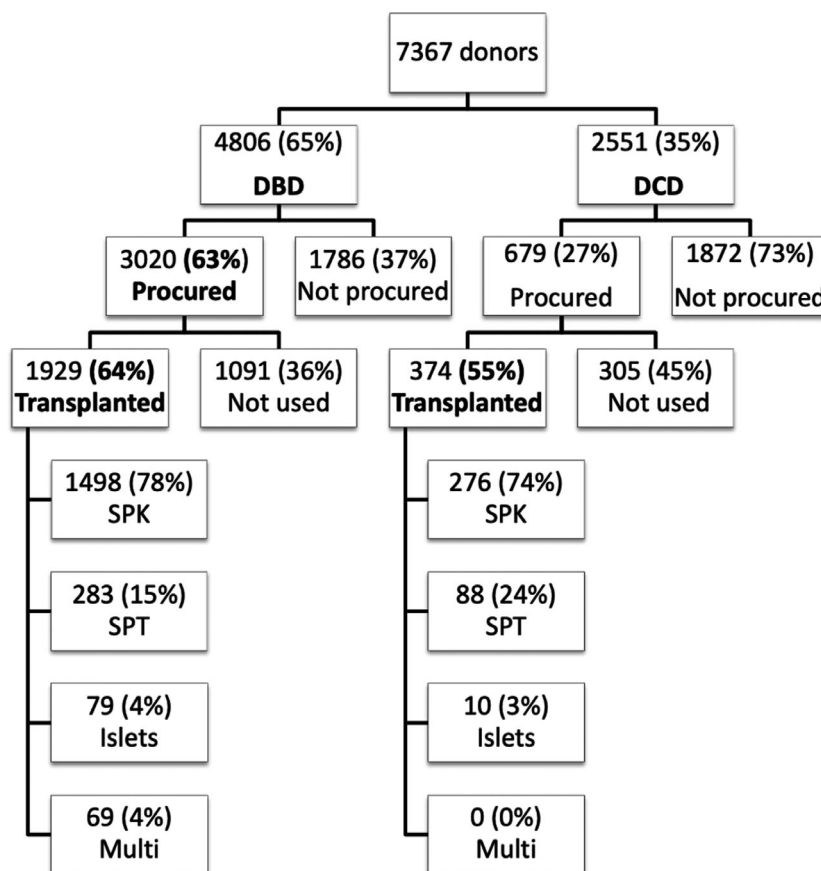
### Results

During the 11-year study period, there were 14 977 potential donors with at least one organ offered for donation; 8036 (53.7%) had the pancreas offered. A pancreas is not always offered from a potential donor because of medical contraindications, age, insulin-dependent diabetes (excluding ICU associated insulin requirement), noninsulin-dependent diabetes (type 2), any history of pancreatic malignancy or donor BMI  $>40 \text{ kg/m}^2$  [17]. General suitability criteria for pancreas donation evolved during this study with a progressive increase in upper age limit from 50 to 60 years old currently.

Our analysis includes 7367 pancreases that were offered first for solid organ transplantation, 4809 of which were from donors after brain death (DBD) and 2558 were from donors after circulatory death (DCD). Of these, 3699 pancreases (50.2%) were retrieved, and only 2303 were transplanted representing 31% of all organs offered for transplantation. 1774 grafts were transplanted as simultaneous pancreas and kidney (SPK) and 371 as solitary pancreas (208 PAK and 163 PTA). 89 grafts were transplanted as islets and 69 were transplanted as a part of multi-organ transplant and therefore were excluded from subsequent analyses. 3668 organs were not retrieved (49.8% of those offered), of which 1789 (37.2%) were DBD and 1879 (73.5%) DCD (Fig. 1). The primary reasons for nonretrieval are shown in Table 1. The annual number of pancreases offered and used is illustrated in Fig. S1.

1396 pancreases were retrieved and subsequently discarded (37.7% of all grafts). The primary reasons for non-transplantation are shown in Table 2. Of all pancreases offered, nearly 40% were not retrieved for medical unsuitability (donor past medical history) as primary refusal reason (table 1). In contrast, 44% of the organs retrieved were not transplanted for clinical reasons, related to organ quality and operative issues, as detailed in Table 2.

A detailed analysis of the clinical reasons showed that the main two reasons for discard were either fatty appearance (44.6%) or damage (23.9%). The donor BMI for the 271 organs discarded because of fatty appearance was  $26.3 \text{ kg/m}^2$  (IQR 24.2–28.4; min: 17.5 –



**Figure 1** Summary of all pancreas offers in the UK (2005-2015) and the eventual outcomes for DBD and DCD organs.

max: 40.4). Other reasons included prolonged ischaemia time (17.1%), poor quality of perfusion (6.1%) or poor function (4.3%; Table 3).

Whilst the pancreas donor risk index (PDRI) is not routinely used in the UK for utilization decision making, we undertook a comparison of the PDRI for the organs not retrieved ( $n = 3668$ ) versus those retrieved ( $n = 3699$ ). There was a significantly lower median PDRI for the organs that were eventually retrieved (1.76, IQR: 1.25–2.28) compared with those not retrieved (2.49, IQR: 1.82–3.14;  $P < 0.0001$ , Wilcoxon–Mann–Whitney test).

#### DBD graft utilization

During the study period, there was a 68% increase in the number of DBD pancreases offered initially for whole organ transplantation, from 269 in 2005 to 452 in 2015, but the overall utilization declined from 42% in 2005 to 36% in 2015. Out of 1396 pancreases retrieved and not transplanted, 1091 were DBD (78%). 928 (52%) DBD pancreases were transplanted on the first offer. A comparison between transplanted and discarded DBD grafts is shown in Table 3. The DBD

pancreas grafts that were eventually transplanted came from significantly younger donors (median 37 years compared to 47 years;  $P < 0.0001$ ), with a lower girth and BMI, ( $P < 0.0001$ ), and fewer cerebrovascular accidents as a cause of death ( $P < 0.0001$ ).

#### DCD graft utilization

A significantly higher proportion of pancreases was not retrieved from DCD donors in comparison to DBD donors (73% DCD vs. 37% DBD, chi-Squared test  $P < 0.0001$ ). 305 DCD pancreases were retrieved and not transplanted. There was an increase in the number of DCD pancreases offered first for whole organ transplantation from 2 in 2005 to 320 in 2015, but the overall utilization was only 18% in 2015, despite a significant increase in the number of DCD donors in the UK. 364 (68%) DCD pancreases were transplanted at the first offer, significantly higher compared with DBD (52%), chi-Squared test  $P < 0.0001$ . A comparison between transplanted and discarded DCD grafts is shown in Table 4. The DCD organs that were transplanted either on a 1st or subsequent offer came from donors who were significantly younger,

**Table 1.** Reasons for nonretrieval of pancreases in the UK.

Reason for nonretrieval	DBD N (%)	DCD N (%)	Total N (%)
Donor unsuitable (medical)	825 (46.1)	620 (33.0)	1445 (39.4)
Past history			1070 (29.17)
Virology			132 (3.60)
Anatomy			95 (2.59)
Medical reason			40 (1.09)
Cause of death			29 (0.79)
Infection			28 (0.76)
Other disease			23 (0.63)
Tumour			15 (0.41)
Medication			12 (0.33)
Cross-match positive			1 (0.03)
Organ unsuitable (clinical)	412 (23.0)	220 (11.7)	632 (17.2)
Fatty organ			262 (7.14)
Poor function*			217 (5.92)
Organ damaged			55 (1.50)
HLA/ABO type			31 (0.85)
Warm ischaemia			25 (0.68)
Organ unsuitable for transplant			22 (0.60)
Cold ischaemia			10 (0.27)
Poor perfusion			8 (0.22)
Contamination			1 (0.03)
Organ fibrotic			1 (0.03)
Others	136 (7.6)	488 <sup>†</sup> (26.0)	624 (17.0)
Donor age	248 (13.9)	289 (15.4)	537 (14.6)
Donor unsuitable (nonmedical)	124 (6.9)	165 (8.8)	289 (7.9)
Donor Size			261 (7.12)
Unstable			16 (0.44)
DCD donor			10 (0.27)
Brain stem tests not satisfied			1 (0.03)
Donor recovered			1 (0.03)
Logistics	33 (1.8)	65 (3.5)	98 (2.7)
No permission	9 (0.5)	31 (1.7)	40 (1.1)
Not reported	2 (0.1)	1 (0.1)	3 (0.1)
Total	1789	1879	3668

\*"Poor function" refers to organ-specific blood tests (amylase and glycaemia) at the point of organ offering.

<sup>†</sup>Includes 317 (65%) with prolonged time to asystole (detailed reasons for clinical and medical unsuitability provided for all organs as available in NHSBT database).

(median 28 years compared to 44 years;  $P < 0.0001$ ), with a lower girth and lower BMI ( $P < 0.0001$ ), and fewer cerebrovascular accidents as a cause of death ( $P < 0.0001$ ).

### Centre variations

1177 (55%) of the 2145 transplants undertaken during the study period were accepted and transplanted on the first offer by the centre at the top of the offering sequence. The remaining 968 (45%) pancreases were accepted and transplanted after a median of three offers (interquartile range 2–5) with no differences between DBD and DCD.

The percentage of offers transplanted by each centre according to the ranking in the offering sequence is

shown in Figs 2 and 3 for DBD and DCD donors, respectively. For DBD, all centres accepted and transplanted more pancreases when offered the organ first (range 10–28%) compared with those organs offered on second or subsequent offers. Only one centre accepted 11% of the pancreases on the final offer (7th).

For DCD, all centres accepted and transplanted at least one organ when offered the organ first, with the overall transplantation rate when ranked first ranging from 2% of offers at centres 3 and 6 to 14% at centre 4.

A comparison of the centre-specific reasons for discarding organs that were subsequently transplanted elsewhere revealed variations in the interpretation of donor data, particularly with regards to the donor medical

**Table 2.** Reasons for nonutilization of the pancreases retrieved in the UK (2005–2015; detailed reasons for clinical and medical unsuitability provided for all organs as available in NHSBT database).

Reason for nonutilization of retrieved pancreases	DBD N (%)	DCD N (%)	Total N (%)
Organ unsuitable (clinical)	476 (43.6)	132 (43.3)	608 (43.6)
Fatty organ			271 (19.41)
Damage			145 (10.39)
Cold ischaemia			102 (7.31)
Poor perfusion			37 (2.65)
Poor function			26 (1.86)
Unsuitable for transplant			11 (0.79)
HLA/ABO type			8 (0.57)
Too small			4 (0.29)
Warm ischaemia			2 (0.14)
Fibrosis			1 (0.07)
Contamination			1 (0.07)
Donor unsuitable (medical)	194 (17.8)	52 (17.1)	246 (17.6)
Anatomy			102 (7.31)
Past history			72 (5.16)
Tumour			22 (1.58)
Other disease			15 (1.07)
Medical reason			13 (0.93)
Cross-match positive			8 (0.57)
Cause of death			5 (0.36)
Virology			4 (0.29)
Infection			4 (0.29)
Medication			1 (0.07)
Unsuitable for islets	193 (17.7)	46 (15.1)	239 (17.1)
Other	130 (11.9)	42 (13.8)	172 (12.3)
Donor age	30 (2.8)	9 (3.0)	39 (2.8)
Research after discard	24 (2.2)	11 (3.6)	35 (2.5)
Recipient	26 (2.4)	2 (0.7)	28 (2.0)
Logistics	8 (0.7)	8 (2.6)	16 (1.2)
Donor unsuitable (nonmedical)	8 (0.7)	3 (1.0)	11 (0.8)
Not reported	2 (0.2)	0 (0.0)	2 (0.1)
Total	1091	305	1396

history and organ quality assessment (Table 5). As centres provide multiple reasons for discarding an offer, this analysis focussed only on the primary reason for discard. For the organs that were eventually transplanted, 26% of offers were discarded during the offering sequence for donor-related medical reasons and 13.7% for organ-related clinical reasons.

A subgroup analysis of the first graft offer to a named patient, which was subsequently transplanted as a SPK or solitary pancreas (SPT) transplant, between 1 December 2010 and 31 December 2015, after the introduction of the NPAS showed significant differences in discard rates between centres. The discard rates ranged from 30.2% to 79.7% for DBD and from 3.2% to 77.8% for DCD (chi-square  $P$ -value <0.001 for both DBD and DCD). The discard rates for the first offer of a pancreas that was subsequently transplanted in a different centre

varied between 18.9% and 77.2%, with no correlation with centre volume (Table 6). The reasons for discarding first offers of a DBD and DCD organ in each centre are summarized in Tables S1 and S2.

The variations in acceptance were not correlated with a statistically significant difference in the five-year graft survival for SPK transplants according to the ranking of acceptance in the offering sequence (Log-rank  $P$ -value = 0.5, data shown in Table S3).

### Impact of the new National Pancreas Allocation Scheme

A logistic regression model showed no statistically significant difference in the proportion of retrieved and transplanted pancreases before and after the introduction of the NPAS (1 January 2005–30 November 2010

**Table 3.** DBD Donor characteristics comparison between organs transplanted and discarded (p-value of statistical significance between the transplanted and not transplanted groups) and comparison between organs transplanted on first offer or subsequent offer.

Variable	Not transplanted (N = 249)	Transplanted (N = 364)	P-value	Transplanted on first offer (N = 249)	Transplanted on subsequent offer (N = 115)
Donor age (year)*	47 (36–54)	37 (24–47)	<0.0001	37 (24–46)	38 (24–47)
Donor girth (cm)*	92 (82–100)	85 (77–93)	<0.0001	84 (76–93)	85 (78–93)
Donor BMI (kg/m <sup>2</sup> )*	25.4 (23.1–27.8)	23.5 (21.5–26.0)	<0.0001	23.4 (21.3–26.0)	23.6 (21.6–25.9)
Past smoker					
Yes	461 (55%)	911 (52%)	0.12	458 (50%)	453 (54%)
No	376 (45%)	847 (48%)		454 (50%)	393 (46%)
Unknown	8	23		16	7
Past drug abuse					
Yes	69 (8%)	160 (9%)	0.5	66 (7%)	94 (11%)
No	757 (92%)	1573 (91%)		836 (93%)	764 (91%)
Unknown	19	48		26	16
Past alcohol abuse					
Yes	113 (14%)	136 (8%)	<0.0001	63 (7%)	73 (9%)
No	716 (86%)	1612 (92%)		848 (93%)	764 (91%)
Unknown	16	33		17	16
Cardiovascular disease					
Yes	33 (4%)	48 (3%)	0.09	24 (3%)	24 (3%)
No	796 (96%)	1708 (97%)		887 (97%)	821 (97%)
Unknown	16	25		17	8
Donor cause of death					
CVA	595 (70%)	1082 (61%)	<0.0001	576 (62%)	506 (59%)
Miscellaneous	161 (19%)	422 (24%)		200 (22%)	222 (26%)
RTA	58 (7%)	183 (10%)		107 (12%)	76 (9%)
Other trauma	31 (4%)	94 (5%)		45 (5%)	49 (6%)

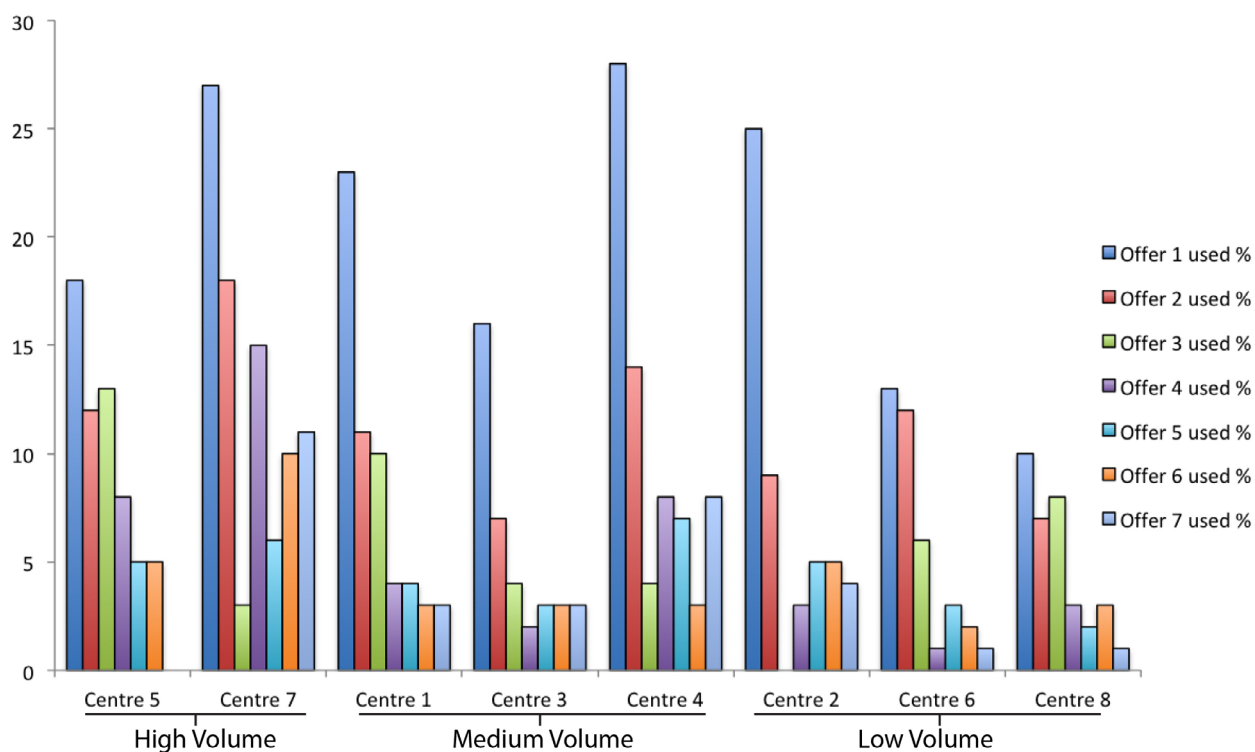
\*Median (IQR).

**Table 4.** DCD donor characteristics comparison between organs transplanted and discarded (p-value of statistical significance between the transplanted and not transplanted groups) and comparison between organs transplanted on first offer or subsequent offer.

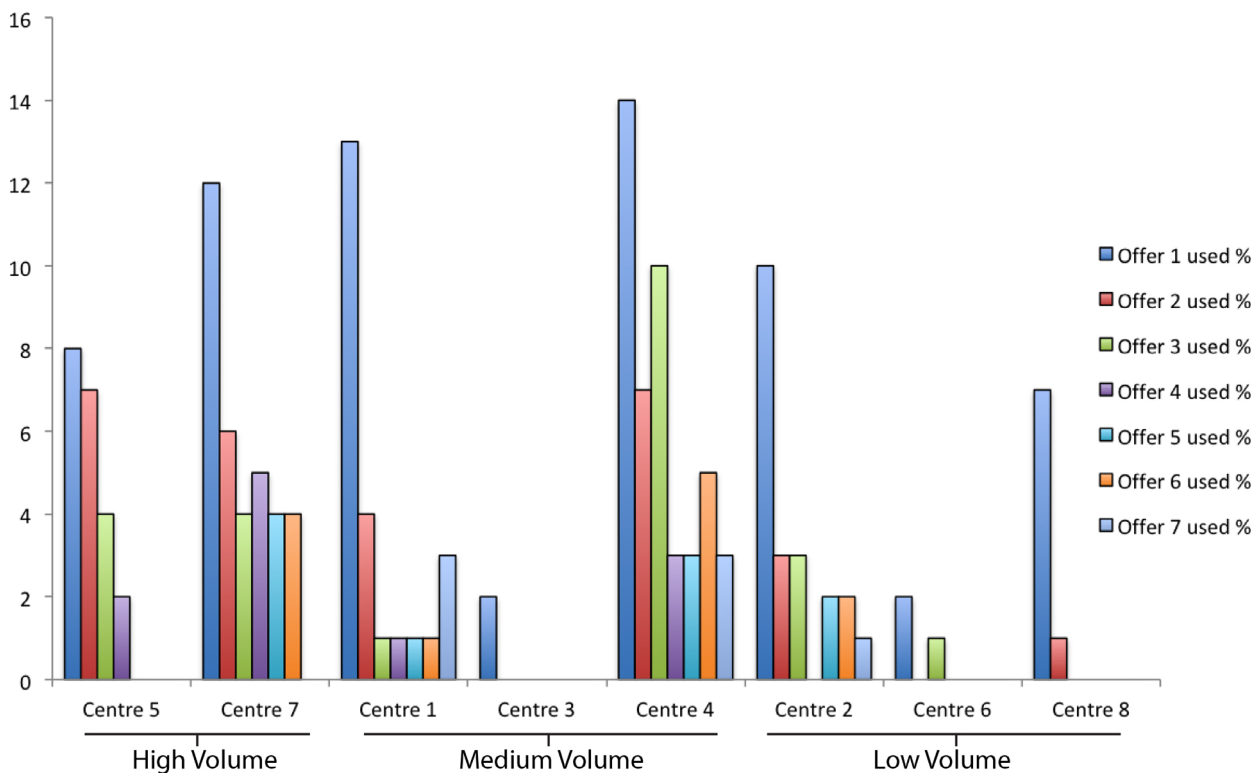
Variable	Not transplanted (N = 249)	Transplanted (N = 364)	P-value	Transplanted on first offer (N = 249)	Transplanted on subsequent offer (N = 115)
Donor age (year)*	44 (31–51)	28 (20–42)	<0.001	29 (20–43)	28 (19–41)
Donor girth (cm)*	92 (84–100)	83 (76–90)	<0.001	82 (76–90)	84.5 (75–90)
Donor BMI kg/m <sup>2</sup> *	24.7 (22.1–27.7)	23.1 (20.5–25.1)	<0.001	23.1 (20.7–25.1)	23.1 (20.2–25.4)
Past smoker					
Yes	120 (49%)	162 (47%)	0.50	108 (46%)	54 (49%)
No	124 (51%)	186 (53%)		129 (54%)	57 (51%)
Unknown	5	16		12	4
Past drug abuse					
Yes	20 (8%)	41 (12%)	0.16	22 (10%)	19 (17%)
No	219 (92%)	302 (88%)		209 (90%)	93 (83%)
Unknown	10	21		18	3
Past alcohol abuse					
Yes	27 (11%)	34 (10%)	0.50	23 (10%)	11 (10%)
No	212 (89%)	317 (90%)		215 (90%)	102 (90%)
Unknown	10	13		11	2
Cardiovascular disease					
Yes	18 (7%)	15 (4%)	0.05	10 (4%)	5 (4%)
No	223 (93%)	334 (96%)		224 (96%)	110 (96%)
Unknown	8	15		15	
Donor cause of death					
CVA	122 (49%)	125 (34%)	0.001	89 (36%)	36 (31%)
Miscellaneous	91 (37%)	154 (42%)		102 (41%)	52 (45%)
RTA	23 (9%)	57 (16%)		40 (16%)	17 (15%)
Other trauma	13 (5%)	28 (8%)		18 (7%)	10 (9%)

\*Median (IQR).





**Figure 2** Percentage of DBD organs offered and transplanted per centre according to the ranking in the offering sequence and centre volume.



**Figure 3** Percentage of DBD organs offered and transplanted per centre according to the ranking in the offering sequence and centre volume.

**Table 5.** Reasons provided by centres for turning down organs subsequently transplanted elsewhere between 1 January 2005 and 31 December 2015.

Reason for discard	Centre 5 (high volume) N (%)	Centre 7 (high volume) N (%)	Centre 1 (medium volume) N (%)	Centre 3 (medium volume) N (%)	Centre 4 (medium volume) N (%)	Centre 2 (low volume) N (%)	Centre 6 (low volume) N (%)	Centre 8 (low volume) N (%)	Total %
Donor unsuitable (medical)*	129 (4.7)	99 (3.6)	57 (2.1)	117 (4.2)	55 (2.0)	49 (1.8)	82 (3.0)	116 (4.2)	26.0
Donor age	14 (0.5)	14 (0.5)	10 (0.4)	22 (0.8)	21 (0.8)	8 (0.3)	15 (0.5)	19 (0.7)	4.5
Donor unsuitable (nonmedical)*	14 (0.5)	19 (0.7)	27 (1.0)	12 (0.4)	7 (0.3)	3 (0.1)	11 (0.4)	34 (1.2)	4.7
Other	51 (1.8)	96 (3.5)	116 (4.2)	97 (3.5)	72 (2.6)	58 (2.1)	57 (2.1)	70 (2.5)	23.0
Logistics	102 (3.7)	132 (4.8)	33 (1.2)	80 (2.9)	24 (0.9)	15 (0.5)	96 (3.5)	37 (1.3)	19.8
Organ unsuitable-clinical	41 (1.5)	51 (1.8)	60 (2.2)	59 (2.1)	28 (1.0)	30 (1.1)	46 (1.7)	55 (2.0)	13.7
Recipient	43 (1.6)	92 (3.3)	17 (0.6)	19 (0.7)	25 (0.9)	7 (0.3)	4 (0.1)	18 (0.7)	8.2
Not reported	—	—	1 (0.0)	1 (0.0)	—	1 (0.0)	—	1 (0.0)	0.1
Total offers	394	503	321	407	232	171	311	350	100.0

\*Encompasses the reasons detailed in Tables 1 and 2.

compared with 1 December 2010–31 December 2015) after adjusting for donor characteristics (donor type, donor age, donor BMI, donor cause of death, donor girth, past smoker status, past drug abuse, past alcohol abuse and past cardiovascular disease). However, this had a favourable impact on islet transplantation with an increase from 13 islet transplants in 2010/2011 to 30 islet transplants in 2011/2012.

#### Discard rates for ideal versus nonideal donor pancreas offers

The number of ideal donor organs offered (defined as age <40 years old, non-CVA as cause of death and BMI <30 kg/m<sup>2</sup>) ranged between 16% and 26% of all donors during the study period. The discard rates of ideal organs offered and retrieved increased during the first 3 years of the study but remained constant thereafter. In contrast, the rates of discard of nonideal donors increased over time, averaging 46% in the last four years of the study (Fig. 4).

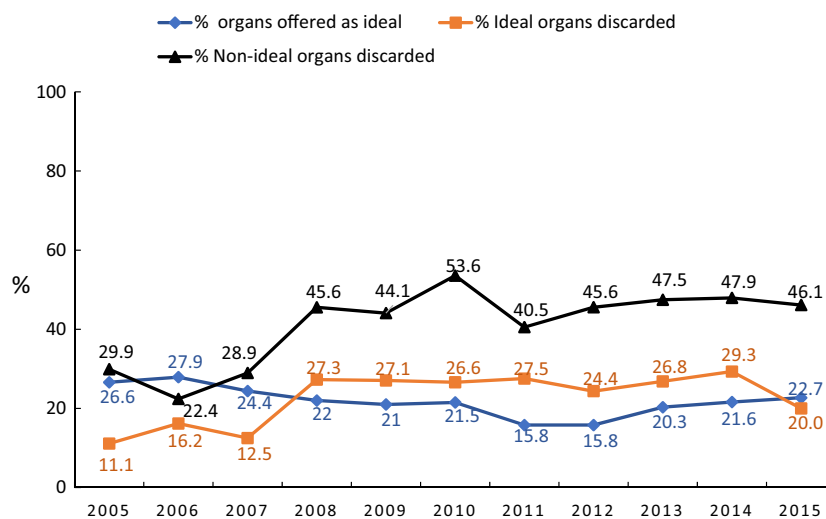
#### Discussion

The pancreas discard rate remains the highest amongst all abdominal solid organs [5,18,19]. Despite significant improvement in the outcomes of all types of pancreas transplantation (SPK, PTA, Pancreas After Kidney) [20], the number of pancreas transplants have decreased dramatically in recent years. A number of factors may have contributed to this discard rate including changes in the donor demographics and increased utilization of more marginal donors, which may not proceed to pancreas donation.

Despite a drive to increase the number of organs considered for transplantation, by expanding utilization criteria, the data presented herein show that in the UK, only 31% of the organs offered have been retrieved and transplanted. Organ utilization has decreased substantially over the 11-year period of this study for DBD as well as DCD. Significant sociodemographics and clinical history differences were noted between the pancreases transplanted and those discarded, indicating that there has been little change in the clinical practice vis-a-vis traditional risk factors such as cardiovascular disease, smoking, BMI and donor age. Nevertheless, a recent UK analysis reported encouraging results with carefully selected controlled DCD pancreas transplantation, suggesting that avoidance of cumulative risk factors can lead to good clinical outcomes [21]. These data are in keeping with the large international variation in

**Table 6.** Centre variation in the discard rates of first offer of organs subsequently transplanted as an SPK or solitary pancreas via the NPAS, 1 December 2010–31 December 2015 (high volume >300 cases; medium volume: 150–300 cases; low volume <150 cases).

Centre (activity volume)	DBD first offer discarded N (%)	DCD first offer discarded N (%)	Total first offer N (%)
5 (high)	96 (44.8)	48 (35.4)	144 (41.7)
7 (high)	283 (41.7)	53 (18.9)	336 (38.1)
1 (medium)	69 (63.8)	36 (19.4)	105 (48.6)
3 (medium)	124 (58.1)	14 (71.4)	138 (59.4)
4 (medium)	43 (30.2)	31 (3.2)	74 (18.9)
2 (low)	31 (38.7)	28 (39.3)	59 (39.0)
6 (low)	30 (56.7)	9 (77.8)	39 (61.5)
8 (low)	123 (79.7)	13 (53.9)	136 (77.2)
Total	799 (52.2)	232 (30.2)	1031

**Figure 4** Comparative annual discard rates between ideal and nonideal grafts. (Ideal grafts defined as <40 years of age, non-CVA cause of death and BMI <30); (◆) – % organs offered and classed as ideal; (■) – % ideal organs offered, retrieved and discarded; (▲) – % nonideal organs offered, retrieved and discarded.

acceptance of pancreases for transplantation, as well as low utilization of DCD or older DBD donors [22], but confirm that the increase in discard rates is primarily driven by nonideal organs.

The new allocation scheme was specifically designed to provide a layer of selectivity of donors offered primarily for whole organ or for islets according to the BMI ( $\leq 30$  for whole organ first and  $>30$  for islets first) to avoid wasting organs that would otherwise be unsuitable for solid organ transplantation. Despite that, 38% of the organs that were retrieved were eventually discarded.

70% of the organs retrieved were discarded either because of a fatty appearance of the graft or retrieval

damage [9]. The assessment of fatty infiltration of the pancreas is rather subjective and difficult to standardize in terms of distribution and degree of infiltration of the graft. However, retrieval damage can be mitigated by an experienced retrieval team with good appreciation of the complex pancreatic anatomy [14]. The national organ retrieval service in the UK with teams led by certified and competent surgeons in multi-organ retrieval based in either liver or pancreas transplant centres has been established and developed to mitigate against organ discards which may be because of lack of organ retrieval team experience.

To improve the assessment of organs at retrieval, in the UK, an ‘always explant policy’ has been

implemented, supported by images of the pancreas focussing on vascular anatomy, parenchymal structure, duodenal integrity and the presence of any retrieval injuries [23]. This policy allows a better assessment of organs at the point of retrieval and hopefully will reduce the discard rates further. The effect of the policy, which was implemented after this study ended, requires further examination.

This study was able to detail the complex reasons [24] for discard and identified centre specific variation as well as inconsistencies in the reasons for discarding the same organ. In this study, 45% of organs have been turned down by at least one centre before being eventually transplanted. The donor characteristics of organs transplanted on the 1st offer and those transplanted on a subsequent offer were comparable, suggesting that other reasons such as lack of suitable patients on the waiting list or recipient condition may play a role in the individual decisions. Furthermore, the centre variations identified in this study appear not to correlate with centre volume. It is important to note that organs accepted later in the offering sequence achieve comparable outcomes suggesting that a number of grafts should be transplanted by all centres avoiding unnecessary discards. To ensure consistency in practice and results, centre performance is monitored and reported as funnel plots. These are reviewed regularly by the Pancreas Advisory Group of NHSBT and investigative action is taken if required. In addition, transplant outcomes are monitored using CUSUM plots that allow activity to be monitored against national performance.

In 2010, the UK introduced a new offering system, which is unique in so far that it combines the allocation of organs to either solid organ pancreas transplantation or islet transplantation. A comparison of utilization before and after the introduction of the scheme did not show an improvement in the utilization of organs for solid pancreas transplant. However, the utilization of the grafts offered initially for solid organ transplantation that was subsequently accepted for islet transplantation has not been investigated.

This study spans an 11-year period during which a number of significant changes occurred, including changes in the donor demographics, an increased reliance on DCD donors in the UK as well as the introduction of a new pancreas offering scheme. Although many of the findings appear consistent over time, it is possible that this analysis does not capture all the nuances of

organ discard and in particular the reasons for it. Nevertheless, this study highlights the need for an accurate recording of these reasons and further analyses of clinical practice and centre variations.

In summary, despite an increased offering of pancreases for transplantation, utilization rates have remained persistently low. The excellent clinical results achieved suggest that there is scope to increase organ utilization and reduce the number of organs that are perhaps discarded unnecessarily.

With a limited acceptable ischaemic time from the point of retrieval to implantation, an accurate pancreas assessment at the time of retrieval could minimize the discard rates, allow timely decisions about suitability for solid organ transplantation and avoid unnecessary shipment of organs. The unique offering scheme in the UK provides the ideal opportunity to maximize organ utilization by transferring organs not suitable for solid organ transplantation to islet isolation programmes.

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### Conflict of interest

The authors of this manuscript have no conflicts of interest to disclose.

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

**Figure S1.** Annual number of pancreas offers and transplants in the UK (2005–2015).

**Table S1.** Reasons for discarding the first offer of a subsequently transplanted DBD organ, by centre.

**Table S2.** Reasons for discarding the first offer of a subsequently transplanted DCD organ, by centre.

**Table S3.** Five year graft survival following whole organ pancreas transplant (SPK or solitary pancreas transplant) between 1 January 2005 and 31 December 2015, according to the ranking of the offer acceptance.

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