Transplant International

Transplant International ISSN 0934-0874

ORIGINAL ARTICLE

National Organ Retrieval Imaging System: results of the pilot study

Mettu S. Reddy,[1] Chandrashekhar Bhati,[2] Desley Neil,[3] Darius F. Mirza[2] and Derek M. Manas[1]

1 Hepatobiliary & Transplant Surgery, Freeman Hospital, Newcastle upon Tyne, UK
2 Liver Unit, Queen Elizabeth Hospital, Birmingham, UK
3 Department of Pathology, Queen Elizabeth Hospital, Birmingham, UK

Keywords
digital images, graft assessment, internet, liver transplantation.

Correspondence
Derek M. Manas, Department of Hepatobiliary & Transplant Surgery, Freeman Hospital, Newcastle upon Tyne, UK. Tel.: +44 191 2231192; fax: +44 191 2231191; e-mail: derek.manas@nuth.nhs.uk

Received: 18 February 2008
Revision requested: 7 March 2008
Accepted: 21 May 2008

doi:10.1111/j.1432-2277.2008.00720.x

Summary

Efficient utilization of marginal liver grafts is dependant on the accurate assessment and relay of graft-related information to recipient units in an organ-sharing network. Currently, information is conveyed by the recovery team over the telephone and can sometimes be inconclusive or incomplete. We have developed a web-based instrument called the National Organ Retrieval Imaging System (NORIS) to improve this assessment process. The aim of this pilot study was to assess the feasibility of real-time data upload and the reliability of web-based remote assessment in identifying donor livers with significant macrosteatosis. Data from 153 donor livers uploaded to the website were analysed. Completeness of graft data uploads, accuracy of on-site and two separate remote assessments using a semi-objective graft score in identifying grafts with moderate or severe macro-vesicular steatosis were analysed. Uploads were complete in all recoveries. Liver grafts with moderate or severe macro-vesicular steatosis had a higher incidence of initial poor function (7/10 vs. 26/86, $P = 0.029$). Organ scores for steatotic grafts were significantly higher than nonsteatotic grafts in all three assessments ($P < 0.001$). Accuracy of the two remote assessors was similar to the actual on-site assessment. There was a substantial degree of inter-observer agreement between the assessments (kappa statistics = 0.658, 0.597, 0.698). Feasibility of real-time data upload and reliability of remote graft assessment have been confirmed.

Introduction

The imbalance between donor and recipient numbers for organ transplantation is increasing worldwide. This has forced transplant surgeons to look at 'marginal' or 'expanded criteria donors' for organ donation [1]. While the use of marginal donors in liver transplantation can decrease mortality on waiting list [2], it is associated with increased risk of primary nonfunction (PNF) and early graft dysfunction. Specifically, moderate and severe macro-vesicular steatosis in the graft liver has been identified as a predictor of poor outcome [3]. Careful matching of marginal donor livers to preferred recipients can decrease the risk to recipients while ensuring optimum usage of organs [4,5].

Donor recovery and recipient transplantation procedures are usually carried out in different, sometimes widely separated, hospitals within an organ-sharing network. In the UK, donor recovery teams were constituted from within the liver transplant unit staff with experience in making reliable on-site graft liver assessment. With new government initiatives to increase donation rates through dedicated organ recovery teams, there will be an inevitable separation between recovery and recipient teams. Graft-related information is currently conveyed by the recovery team over the telephone and can sometimes

be inconclusive or incomplete. When this information is used to place the donor liver, errors in donor–recipient matching can arise leading to poor results.

To address some of these concerns, we have developed a web-based instrument that enables digital images of the graft along with donor and graft-related information to be transmitted in real-time to multiple transplant units. The National Organ Retrieval Imaging System (NORIS) accessible at www.noris.org.uk is currently being piloted by two liver transplant units in the UK.

The aim of this pilot study was to assess the feasibility of real-time upload of graft-related information and to assess whether the information uploaded is adequate to make an accurate assessment of graft quality by a remote surgeon.

Materials and methods

NORIS assessment loop

At the time of recovery, multiple digital images of the liver are taken (Fig. 1). The recovery team accesses the internet using a portable computer with wireless internet connection. They complete the on-line graft data form and upload images of the graft. On-call surgeon(s) at one or more transplant centres in an organ-sharing network are alerted via a cellular phone text message or pager message that a graft is available for assessment and placement. The recipient surgeon connects to the Internet and logs onto the NORIS website using a secure password. The surgeon reviews the uploaded images and data and decides whether to accept/reject the liver (Fig. 2). The surgeon can also contact the recovery team to ask for more information or specific images. The recovery team receives the message and performs the necessary tasks as per the surgeon's request.

Technical details of image capture

Camera settings

A commercially available digital camera was used to take the pictures. The camera is white-balanced automatically and used in the Macro mode. The graft is photographed from a distance of approximately 30 cm with flash and with the operating lights turned away from the graft. The zoom facility is used to take detailed pictures of vascular anatomy or surface lesions.

Timing and number of images

Pictures of the graft were taken both *in situ* before aortic cross-clamp and on the back-table after portal flush. On average, six images were taken of each graft. Pictures of the anterior and posterior surface of the liver and one picture clearly showing the inferior edges of the left and right lobes were taken. Additional images of any vascular anomaly or injuries and surface lesions were also taken. Livers which were split had multiple images of the splitting process with close-up views showing the length and size of vessels with each split graft. Photographs were taken with the liver completely out of the preservation fluid to minimize refraction artefacts.

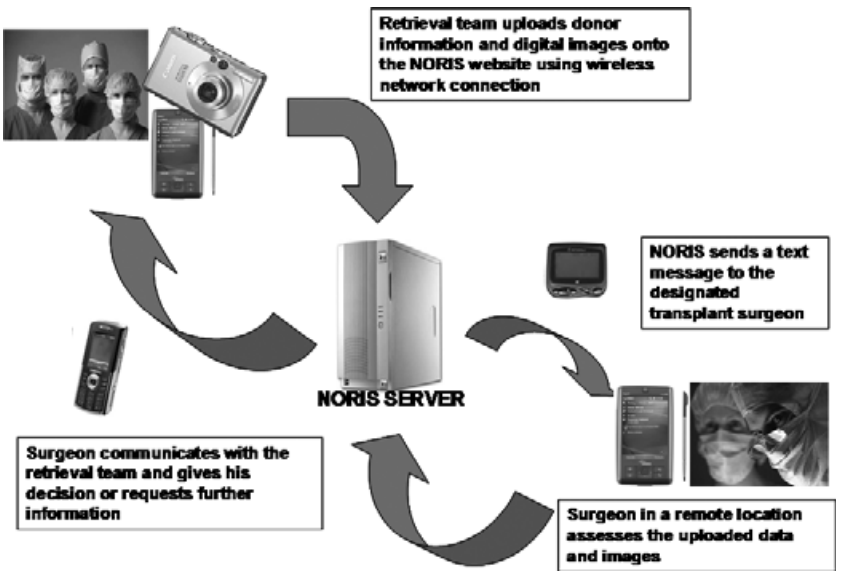

Figure 1 Schematic overview of the course of events during the use of NORIS in an organ sharing network.

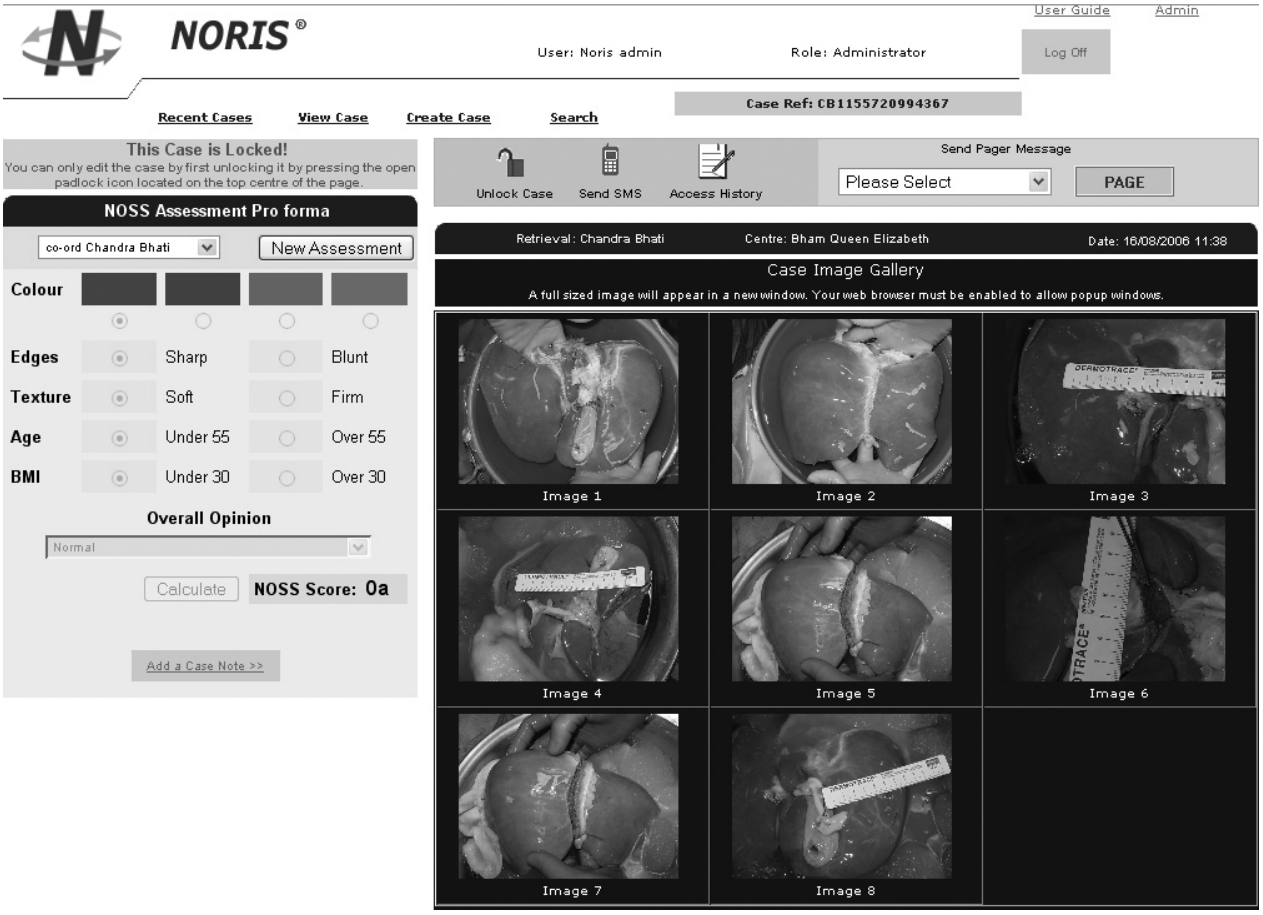

Figure 2 Screen shot of the NORIS webpage at the recipient surgeon's terminal.

Graft data sheet and Graft score

At each organ recovery, basic donor and graft-related data in the form of five variables: donor age (<55 or ≥55 years), donor body mass index (≥30 or <30), graft colour (chosen from an on-screen palette), edges (sharp or rounded), texture (soft or firm) was entered in the graft score sheet. Each upload sheet also included a free text area that was used to convey any other information considered relevant to the particular case. The data entered were used to calculate a Graft score**.** The score is calculated giving equal weighting to the five uploaded variables (Table 1).

Table 1. Calculation of the Graft score.

Assessment criteria	Points awarded for each criterion			
	0	1	2	3
Donor age	<55	>55	–	–
Donor BMI	<30	>30	–	–
Graft colour	Chosen from an onscreen palette (points from 0 to 3)			
Border	Sharp	Blunt	–	–
Consistency	Soft	Firm	–	–
Visual assessment	Nil steatosis	Mild steatosis	Moderate steatosis	Severe steatosis

Graft score = sum of individual scores (range: 0–10).

Data security and confidentiality

Data are encrypted before transfer to protect patient confidentiality. Information is also stored in an encrypted form and no patient identifiable data are stored on the NORIS server. There is a full audit trail of all changes made to every case as well as a log of every user who has access to the system.

Data collection

The system has been online since late 2004. By December 2006, data from 153 grafts were uploaded to the website by the two participating transplant units. In the

case of unit A, data were collected and uploaded at the time of the recovery operation in majority of cases ($n = 46/49$). In unit B, data were collected and uploaded at the time of back-table preparation of the liver graft ($n = 104/104$). Multiple pictures showing the back-table splitting process were uploaded for liver grafts that were split ($n = 18$, all in unit B). This included detailed images showing the vascular anatomy of each split liver. On-site graft assessment was performed by the recovery surgeon (unit A) or on-call recipient surgeon (unit B).

For the purpose of this study, two liver transplant surgeons accessed the NORIS website independently and viewed the uploaded grafts at a later date. Each completed his own assessment of graft quality on the basis of uploaded images and data. The surgeons were blinded to the on-site assessment, post-transplant outcome and implantation biopsy data. The graft scores for the initial on-site assessment and the two remote assessments were calculated.

For grafts transplanted within the two participating units, a single core-needle biopsy was taken from the implanted liver before abdominal closure and fixed in formalin. Extent of steatosis in the donor liver biopsy was reported both quantitatively (nil < 5%, mild = 5–30%, moderate = 31–60%, severe 61–100%) and qualitatively (micro-vesicular or macro-vesicular steatosis). Data regarding graft utilization (transplanted/discarded, whole-graft/split-graft), UK Transplant classification of the recipient status (routine/super-urgent), donor and recipient demographics, actual graft steatosis (from implantation biopsy), and post-transplant graft function were collected. PNF was defined as graft dysfunction leading to death or re-transplantation within 1 week of transplantation. Initial poor function (IPF) was defined as a peak prothrombin time >16 s and liver enzyme (Alanine amino transferase or Aspartate amino transferase) levels >2000 U/l between days 2–7 post-transplantation [6].

For the purpose of this article, the term 'macrosteatotic graft' will hereafter be used to refer to donor livers with moderate and severe macro-vesicular steatosis on biopsy. Rest of the livers will be referred to as 'nonsteatotic grafts'.

Statistical analysis

Data are presented as median (inter-quartile range) for continuous variables and frequency (percentage) for discrete variables. Graft outcomes were compared between macrosteatotic and nonsteatotic grafts using Fisher's exact test. Graft scores of all three assessors for macrosteatotic and nonsteatotic grafts were compared using the Mann–Whitney *U*-test. Receiver operating characteristic (ROC) curve analysis was used to compare the accuracy of the three assessors in identifying macrosteatotic grafts. κ-Statistic was used to assess the degree of inter-observer agreement between the individual assessments. SPSS version 14.0 (SPSS, Chicago, IL, USA) was used for all analyses.

Results

Data upload

Donor and graft data entry in the NORIS website was complete for all recovery procedures. Six (IQR 5–8) images were uploaded for each donor liver. Uploaded images were unsatisfactory in two cases. All livers had a completed onsite assessment. 133 grafts (excluding 18 split livers and two unsatisfactory uploads) were separately assessed by the two remote assessors.

Correlation between onsite and remote assessments for 133 uploads

There was a significant correlation between the scoring patterns of onsite and remote assessors (Spearman's correlation coefficient: 0.666, 0.692, 0.716; $P = 0.01$).

Graft utilization (Fig. 3 and Table 2)

Split grafts ($n = 18$)

These were assessed by the on-site surgeon as nonsteatotic ($n = 17$) or mildly steatotic ($n = 1$) with a median graft score of 0 (0–1).

Locally transplanted whole liver grafts ($n = 105$)

Post-transplant outcome data were available for these grafts. Fat biopsy data were available for 96 grafts. Based on onsite assessment, 43 livers were considered nil steatotic, 40 livers mildly steatotic, 15 moderately steatotic and seven severely steatotic. Median graft scores for onsite assessment were 2(1–4) and those for remote assessments were 2(0–3), 3(1–4).

Exported grafts ($n = 19$)

Exported grafts were more likely to have been assessed during onsite assessment as being moderately or severely steatotic than grafts used locally (10/19 vs. 21/105, Fishers's exact test, $P = 0.027$). However, there was no significant difference in the graft scores (onsite and remote assessments) for these livers compared to the grafts utilized locally (Table 5). Data regarding actual graft steatosis were not available for these livers. Clinical outcome data were available for eight grafts.

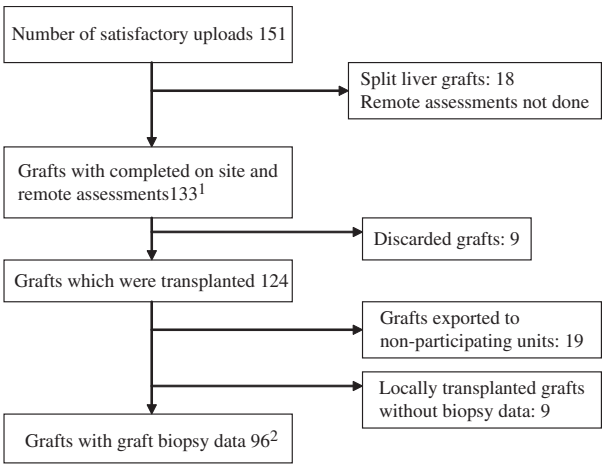

Figure 3 Flowchart showing the fate of 151 liver grafts uploaded on the NORIS system. [1]Data from 133 grafts were used for analysing the degree of correlation and degree of agreement between the on-site and remote assessments. [2]Data from 96 grafts were used to analyse correlation between actual graft steatosis and post-transplant outcome, actual graft steatosis and on-site and remote graft assessments and discriminatory power of graft score to identify macro-steatotic grafts.

Nontransplanted grafts (n = 9)

Onsite surgeon's assessment, graft scores, graft biopsy data (if available), associated donor complicating factors and graft outcome are detailed in Table 3. The reason was significant steatosis with additional complicating factors in eight cases and donor malignancy (renal cell carcinoma) in one case. Graft scores for the discarded steatotic livers were significantly higher than the scores for transplanted livers in all three assessments (Mann–Whitney *U*-test, $P = 0.001$).

Extent of steatosis on implantation biopsy

Biopsy data were available for 97 livers (95 transplanted, 2 discarded). Sixty-four grafts (66%) had nil ($n = 36$) or mild ($n = 28$) steatosis on biopsy. Eighteen grafts (18.6%) had moderate steatosis, while 15 grafts (15.5%) had severe steatosis. In grafts with moderate or severe steatosis, 21 grafts had predominantly micro-vesicular steatosis, while 12 (12.4% of all grafts) had predominantly macro-vesicular steatosis.

Post-transplant outcome and relation to actual graft steatosis

Post-transplant outcomes of macrosteatotic grafts ($n = 10$) and nonsteatotic grafts ($n = 86$) were compared (Tables 4 and 5). There was a significantly higher incidence of IPF in recipients transplanted with macrosteatotic grafts (Fisher exact test; $P = 0.029$). There was no significant difference in PNF, hepatic artery thrombosis or re-transplantation between macrosteatotic and nonsteatotic grafts.

Correlation between graft assessments and actual graft steatosis

There was moderate to substantial correlation between the graft scores and actual graft steatosis (Spearman's correlation coefficients: 0.503, 0.640 and 0.639; $P < 0.001$ for the three assessments). The graft scores for macrosteatotic grafts were significantly higher than the scores for nonsteatotic grafts (Table 2; Mann–Whitney *U*-test, $P = 0.001$ for all three assessments). ROC analysis revealed that a graft score ≥5 had the best discriminatory power to identify macrosteatotic grafts in both on-site assessment (area under curve: 0.829) and remote assessments (area under curves: 0.802 and 0.907).

Degree of inter-assessor agreement

Analysis of the scoring patterns (score <5 or ≥5) of the three assessors showed that there was a substantial degree of agreement between the two remote assessments (κ-statistic = 0.698) and between the on-site and remote assessments (κ-statistics = 0.658 and 0.597).

Table 2. Comparison of onsite and remote assessments of liver grafts based on graft utilization outcome.

			Graft scores		
Outcome of graft	Locally used or exported	Steatosis on graft biopsy	Onsite assessment	Remote assessment A	Remote assessment B
Transplanted grafts (124)			3 (1–4)	2 (0–3)	3 (1–4)
	Grafts used locally (105)		2 (1–4)	2 (0–3)	3 (1–4)
		Nonsteatotic (86)	2 (1–4)	2 (0–3)	3 (1–4)
		Macrosteatotic (10)	6 (3–8)	5 (2–6)	6 (4–6)
	Exported grafts (19)		4 (2–5)	2 (1–4)	3 (3–5)
Discarded grafts (9)			8 (5–9)	6 (4–8)	5 (4–8)

Data presented as median (inter-quartile range).

Table 3. Onsite and remote assessments, complication donor factors, biopsy data and outcome of 10 nontransplanted liver grafts.

No.	Onsite assessment of steatosis	Graft score			Complicating factors in donor	Graft biopsy	Graft outcome
		Onsite surgeon	Remote consultant A	Remote consultant B			
1	Moderate	6	5	3	Underwent radical hysterectomy for cervical carcinoma 8 years previously. Moderate ascites and pericardial effusion found on laparotomy	Not done	Could not be placed. Discarded
2	Mild	4	3	4		60% macro-vesicular steatosis	Matched to a super-urgent recipient. Not transplanted based on biopsy result.
3	Severe	8	4	6	Donor was 1 month postpartum. Fatal cere bro-vascular accident	Not done	Could not be placed, sent for research
4	Severe	7	6	5	Elderly obese donor. Nodule on surface of liver. Biopsy suggestive of bile duct ade noma	Not done	Discarded
5	Severe	10	8	8		Not done	Discarded
6	Severe	8	6	7		Not done	Discarded
7	Severe	9	8	9		95% macro-vesicular steatosis	Discarded
8	Severe	8	7	6	History of recent alcohol abuse in donor. Insitu appearance of severe steatosis after aortic perfusion	Not done	Not recovered
9	Mild	3	4	4	Lesion in kidney present. Was confirmed as renal cell carcinoma	40% microvesicular steatosis	Discarded

Table 4. Clinical data of 113 grafts transplanted as whole liver grafts within the participating units (n = 105) or exported (n = 8).

Donor age (years)	45 (33–57)
Donor gender (male, female)	70, 43
Cause of donor death	
Cardio or cerebro-vascular	67 (59.3%)
Trauma with head injury	24 (21.2%)
Others	22 (19.5%)
Recipient age (years)	50.6 (44–60.6)
Urgency of transplant (routine, super-urgent)	103, 10
Pretransplant MELD score	14 (10,20)
Aetiology of liver disease	
Alcohol liver disease	24 (21.2%)
Hepatitis B or C	21 (18.6%)
Paracetomol overdose	6 (5.3%)
Other causes	58 (51.3%)
Re-transplantation	4 (3.5%)
Post-transplant data	
Primary nonfunction	5 (4.4%)
Early graft dysfunction	37 (32.7%)
Hepatic artery thrombosis	2 (2.1%)
30-day mortality	4 (3.5%)
Retransplantation	9 (8.0%)
Median follow up in months	16.3 (12,20.6)
Death till follow up	10 (8.8%)

Data presented as median (inter-quartile range) or number (percentage).

Table 5. Comparison of post-transplant outcomes of 96 grafts with biopsy data.

	Macrosteatotic grafts* (10)	Nonsteatotic grafts (86)	*P*-value†
Primary nonfunction	1	3	0.361
Initial poor function	7	26	0.029
Hepatic artery thrombosis	0	2	ns
Re-transplantation	1	7	ns
Deaths at follow-up (16 months)	1	8	ns

*Grafts with moderate or severe macro-vesicular steatosis.
†Fisher Exact test.

Correlation between graft assessments and post-transplant outcome

Grafts that developed PNF had higher assessment scores than grafts without the complication, but the difference was not statistically significant (Table 6).

Discussion

The current emphasis all over the world is on better utilization of extended criteria donors [7] for transplantation. Accurate assessment of graft quality at recovery and precise transmission of this information to recipient transplant units are essential for selecting suitable recipients. The purpose of NORIS is to aid this process of assessment and reporting by providing graft information in the form of high quality digital images to the recipient surgeon. This places the surgeon in a much better position to select recipients for a graft while balancing the risks and benefits of transplanting a marginal liver. Utilization of digital images and web based technologies has been reported in plastic surgery [8,9] and orthopaedics [10]. A pilot study in the utility of digital photographs for the assessment of renal grafts has been reported [11]. NORIS is the first instance this technology has been used in donor liver assessment.

Table 6. Comparison of onsite and remote assessments of 113 transplanted whole liver grafts with relation to the post-transplant outcome.

Clinical outcome		Onsite assessment	Remote assessment 1	Remote assessment 2
Primary nonfunction	Yes (5)	4 (1–6.5)	4 (1–5.5)	5 (1–5.5)
	No (108)	2 (1–4)	2 (0–3)	3 (1–4)
Initial poor function	Yes (37)	3 (2–5.5)	2 (1–5.5)	4 (3–6)
	No (76)	2 (1–4)	2 (0–2)	4 (3–6)
Retransplantation	Yes (9)	2 (0–4)	2 (0–4)	3 (1–4)
	No (104)	2 (1–4)	2 (0–3)	3 (1–5)
Status at follow-up	Alive (103)	2 (1–4)	2 (0–3)	3 (1–4)
	Dead (10)	2.5 (1–4)	2 (0–5)	2 (1–5)

From the initial developmental stages, the aim has been to simplify the procedure to ensure compliance by the recovery team. Although sending high quality pictures as MMS messages was initially considered it was felt that it cannot provide the security, archival and review capabilities which a website based system can provide. We initially experimented with using a mobile phone with camera for uploading pictures to the website. However, the PDA operating system was complicated and it was decided to continue with a camera and laptop for uploads. The entire kit for the system is contained in a single bag which also contains a basic instruction sheet for new users. With advances in mobile phone capability and the development of user-friendly mobile internet protocols it is expected that NORIS too will move to a single device capable of image capture, data upload and remote case review.

During this pilot study, we attempted to standardize protocols to obtain the best possible mix of image quality and ease of use. Initially, digital images at various resolutions were assessed for clarity. For onscreen viewing, we found no perceptible difference in clarity between 1MP and 3 MP images. As the picture upload and download times for higher resolution images were longer, it was decided to limit each picture to 1 MP. Lighting around the graft had a profound effect on the perceived colour of the graft. Excessive glare from the theatre light made the

graft look more yellow than it actually was, while poor ambient lighting made the graft look much darker. To minimize these variations, grafts are photographed with the operating lights turned away and the camera set with flash on. During the pilot, although uploads from one centre included images of grafts both within the donor (before aortic cross-clamp) and on the back-table, our retrospective review has suggested that in-situ images do not add much to the information provided by back-table pictures.

The graft score used in NORIS has a limited number of variables to simplify on-site data upload. Our aim was to ensure that the recipient surgeon has all the information that is normally provided when a liver is offered along with additional information in the form of images and keeping it simple enough to be completed on-site. Donor age [12] and obesity [13] are known predictors of graft quality. Details of graft appearance such as colour and texture have been incorporated in the score to model a global assessment of graft quality. The graft score was based on these variables. It is a semi-objective score and only intended to be used as an indicator of the number of adverse factors associated with a particular graft rather than a validated score of graft quality. Such semi-objective methods of graft assessment have been previously reported to improve graft assessment [12,14]. The graft score is still a work in progress. Work is being done to improve the on-screen palette to provide better options to match graft colour. Additional data such as weight of the graft are being considered for inclusion in the datasheet. It is hoped that when the planned UK wide use of the system starts and each graft upload is linked to the comprehensive donor database maintained by UK Transplant, there will be sufficient data to support a comprehensive analysis and score validation.

The main drawback of this pilot study is that it does not completely replicate the environment in which the system is expected to be used. While NORIS has been developed to aid remote real-time assessment of the donor livers by the on-call surgeons, the remote assessments for the purpose of this study have been done in controlled conditions. In no instance was the graft placement completed solely on the basis of the NORIS uploads. Real-time data and the true impact of NORIS on liver allocation will only be available when it is taken up in all units in an organ sharing network and used alongside existing protocols.

Plans to utilize NORIS in the assessment of every donor liver recovered in the UK are now at an advanced stage. Once established, it can provide recipient transplant surgeons with high-quality graft-related information even before the liver graft leaves the donor hospital. It also has the potential to become a useful teaching aid for trainee transplant surgeons by its ability to correlate graft appearance with actual graft quality and transplant outcome.

In conclusion, this pilot study has demonstrated the technical feasibility of real-time upload of graft data during the recovery or transplant procedure across two separate transplant units. We have shown that the uploaded data and images are adequate for a surgeon to assess graft quality remotely with accuracy similar to actual on-site assessment.

Authorship

MSR, DMM: designed study, performed research, collected data, analysed data, wrote paper. CB, DN: performed research, collected data, wrote paper. DFM: designed research, performed research, collected data, wrote paper.

Funding source

The project was pump-primed by LIVErNORTH.

Hardware costs are being supported by an educational grant from Astellas.

NORIS server is maintained jointly by UK Transplant and MindAscent.

Acknowledgements

We thank MindAscent Mobile Technology Solutions Ltd for the maintenance of the NORIS website and Mr Aftab Bhatti for his involvement in the initial development of the system.

References

1. Alkofer B, Samstein B, Guarrera JV, *et al.* Extended-donor criteria liver allografts. *Semin Liver Dis* 2006; **26**: 221.
2. Barshes NR, Horwitz IB, Franzini L, Vierling JM, Goss JA. Waitlist mortality decreases with increased use of extended criteria donor liver grafts at adult liver transplant centers. *Am J Transplant* 2007; **7**: 1265.
3. Zamboni F, Franchello A, David E, *et al.* Effect of macrovescicular steatosis and other donor and recipient characteristics on the outcome of liver transplantation. *Clin Transplant* 2001; **15**: 53.
4. Segev DL, Maley WR, Simpkins CE, *et al.* Minimizing risk associated with elderly liver donors by matching to preferred recipients. *Hepatology* 2007; **46**: 1907.
5. Cameron AM, Ghobrial RM, Yersiz H, *et al.* Optimal utilization of donor grafts with extended criteria: a single-center experience in over 1000 liver transplants. *Ann Surg* 2006; **243**: 748.

6. Ploeg RJ, D'Alessandro AM, Knechtle SJ, *et al.* Risk factors for primary dysfunction after liver transplantation – a multivariate analysis. *Transplantation* 1993; **55**: 807.
7. Foster R, Zimmerman M, Trotter JF. Expanding donor options: marginal, living, and split donors. *Clin Liver Dis* 2007; **11**: 417.
8. Murphy RX, Jr, Bain MA, Wasser TE, Wilson E, Okunski WJ. The reliability of digital imaging in the remote assessment of wounds: defining a standard. *Ann Plast Surg* 2006; **56**: 431.
9. Buntic RF, Siko PP, Buncke GM, Ruebeck D, Kind GM, Buncke HJ. Using the Internet for rapid exchange of photographs and X-ray images to evaluate potential extremity replantation candidates. *J Trauma* 1997; **43**: 342.
10. Ricci WM, Borrelli J. Teleradiology in orthopaedics. *Clin Orthop Relat Res* 2004; **421**: 64.
11. Edwards AG, Weale AR, Morgan JD, Rudge CJ. A pilot study to assess the use of digital photography in renal transplantation. *Transplantation* 2005; **80**: 875.
12. Feng S, Goodrich NP, Bragg-Gresham JL, *et al.* Characteristics associated with liver graft failure: the concept of a donor risk index. *Am J Transplant* 2006; **6**: 783.
13. Rinella ME, Alonso E, Rao S, *et al.* Body mass index as a predictor of hepatic steatosis in living liver donors. *Liver Transpl* 2001; **7**: 409.
14. Pareja-Ciuro F, Alamo-Martinez JM, Barrera-Pulido L, *et al.* Scoring guide when deciding to accept an organ for a liver transplant. *Transplant Proc* 2006; **38**: 2382.