Predicting early allograft function after normothermic machine perfusion:

Supplementary digital content

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SDC: Statistical methods

Descriptive analysis of variables was done using Prism version 7 (GraphPad software, La Jolla, CA, USA) and further descriptive analysis and linear regression models were carried out in SAS version 7.13 (SAS Institute Inc., Cary, NC, USA). Distributions of continuous variables were compared between transplanted and non-transplanted livers using the Mann-Whitney U test, and Fisher’s Exact Test was used for categorical variables. Survival analysis was performed using the Kaplan Meier method.

Linear regression models with MEAF scores as outcomes, regressed on the perfusion variables, were fitted after first normalising the outcome variables of interest. MEAF differed significantly from a normal distribution. The best fitting transformation for the MEAF score was a square root transformation. Univariable linear regression models were fitted with each of the perfusion variables in turn as the exposure variable. For perfusion variables that had skewed distributions and all positive values, the natural log-transform of the variable was also considered as a predictor and if this was more strongly associated with the viability score than the variable on the original scale then this association is reported instead. The perfusion variables that showed the strongest associations with the MEAF score in univariable models were then considered as candidate variables to build a multivariable model for the prediction of the MEAF score.

For the model selection process for the multivariable model, analysis was restricted to the patients who had complete data on all of the candidate variables to be considered for inclusion in the model (the complete case dataset). The distribution of the MEAF score was assessed for normality in the complete case dataset and it was found that a square-root transformation of the MEAF best fitted a Normal Distribution. Therefore, the square-root of the MEAF score was used as the outcome variable in the linear regression model, as it was in the exploratory analysis.

Univariable linear regression models with each of the candidate variables as covariates and the square-root of the MEAF score as the outcome variable were fitted in turn in the complete case dataset and the candidate variables were ranked in order of the strength of their association with the MEAF score. Each of the candidate variables were then added one at a time to a multivariable linear regression model, with the most strongly associated variables
from univariable models included first, and each time a variable was added it was retained in the model if it significantly improved the model fit (at the p<0.1 level). Any variables with effects becoming non-significant on adding new variables to the multivariable model were removed. The final model was arrived at once there was no further improvement in model fit from addition of any of the other candidate variables.

For the 42 cases which were excluded from the multivariable analysis because of missing values from the dataset, those missing variables were as follows:

- ALT at 60 minutes n=9
- ALT at 120 minutes n=15
- Glucose rate of fall n=1
- Lactate at 3 hours n=2
- Lactate at 4 hours n=4
- Bile volume at 2 hours n=3
- Bile volume at 3 hours n=6
- Bile volume at 4 hours n=1
- Bile perfusate glucose peak difference n=1

There were no livers where there were missing data for bicarbonate administration, lactate at 1 and 2 hours, lowest bile glucose or peak bile pH.
Table S1: Reasons for discarding 49 livers that underwent NESLiP

| Reason for turning down liver                  | DBD | DCD |
|-----------------------------------------------|-----|-----|
| ALT >6000                                     | 6   | 15  |
| Bile chemistry                                |     | 16  |
| Bile chemistry and perfusate lactate          |     | 1   |
| High perfusate lactate                        |     | 1   |
| Poor perfusion on machine                     |     | 2 (both steatotic) |
| Steatosis                                     | 1   |     |
| Failure to metabolise glucose                 | 1   | 1   |
| Fibrotic appearance                           |     | 1   |
| Donor history                                 |     | 1   |
| Recipient death, no other centre accepted liver (blood group AB) | 1   |     |
| Damage to bile duct                           |     | 1   |
| Clots in circuit from retrieval               |     | 1   |

Biopsies were not done in any of these livers to aid in decision making.
Table S2. Cause of death or graft loss and MEAF at transplant

| Day post transplant | Graft loss or death | MEAF | Cause                                                                                           |
|---------------------|---------------------|------|-------------------------------------------------------------------------------------------------|
| 0                   | Death               | 0    | Intraoperative cardiac arrest secondary to pulmonary embolism. NESLiP begun while this was being managed |
| 0                   | Death               | 0    | Cardiac arrest during hepatectomy with massive blood loss                                        |
| 0                   | Death               | 0    | Complications during hepatectomy                                                                |
| 2                   | Death               | 2    | Cardiac arrest on background of severe pulmonary hypertension                                    |
| 2                   | Graft loss          | 2    | Primary non function                                                                            |
| 3                   | Graft loss          | 5.7  | Steatotic liver with massive subcapsular haemorrhage on reperfusion requiring packing with consequent ischaemia |
| 5                   | Graft loss          | 4.4  | Hepatic artery thrombosis                                                                        |
| 9                   | Graft loss          | 2.4  | Fulminant antibody mediated rejection                                                             |
| 20                  | Graft loss          | 5.4  | Hepatic artery thrombosis                                                                        |
| 32                  | Death               | 4.9  | Multi-organ failure with sepsis                                                                  |
| 45                  | Death               | 5.6  | Multi-organ failure and venous outflow stenosis                                                   |
| 57                  | Death               | 3.2  | Multi-organ failure and venous outflow stenosis                                                   |
| 95                  | Death               | 8.1  | Multi-organ failure                                                                              |
| 153                 | Death               | 1.6  | Chronic rejection                                                                                |
| 229                 | Graft loss          | 7.9  | Cholangiopathy; died day 306 from sepsis                                                          |
| 360                 | Graft loss          | 4.2  | Cholangiopathy secondary to hepatic artery thrombosis                                             |

Note: No MEAF available for first 3 cases as did not survive 3 days.
Table S3. Number of livers perfused and transplanted, or not transplanted, with variables previously reported by us to be associated with a successful transplant.

| Hepatocyte variables | Cholangiocyte variables | Number of livers |
|----------------------|-------------------------|------------------|
| Alkaline transaminase <6000iu/L at 2 hours | Rate of lactate fall >4mmol/L/h/kg | Glucose concentration ≤80mmol/L | Sodium bicarbonate use ≤30mmol/L | Peak pH >7.5 | Bile glucose ≤3mmol/L | Perfusate-bile concentration ≥10mmol/L | Livers donated after donor brain death | Livers donated after donor circulatory death |
| ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | Used | Not used | Used | Not used |
| ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | 31 | 1 | 23 | 1 |
| ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | X | 4 | 16 | 1 |
| ✔ | ✔ | ✔ | ✔ | ✔ | X | X | 3 | 3 | 7 | 2 |
| ✔ | ✔ | ✔ | ✔ | X | X | X | 2 | 1 | 1 |
| ✔ | ✔ | ✔ | ° | ° | ° | o | 1 | 1 | 1 |
| ✔ | ✔ | ✔ | ✔ | X | X | X | 1 | 1 |
| ✔ | ✔ | ✔ | X | ✔ | ✔ | ✔ | 6 | 3 | 1 |
| ✔ | ✔ | ° | ° | ° | X | X | 8 | 1 |
| ✔ | ° | X | ✔ | ✔ | ✔ | ✔ | 1 | 3 | 1 |
| ✔ | ° | X | ✔ | ✔ | ✔ | ° | 1 | 1 |
| ✔ | ° | ° | ° | ° | ° | ° | 1 | 8 | 3 |
| ✔ | ° | ° | ° | ° | ° | ° | 1 | 4 | 6 |
| ✔ | ° | ° | ° | ° | X | X | 1 | 1 | 4 |
| ✔ | ° | ° | ° | ° | ° | ° | 2 | 1 |
| ✔ | ° | X | ° | ° | ° | X | 1 | 1 |
| ✔ | ° | X | ° | ° | ° | X | 1 | 1 |
| ✔ | ° | ° | ° | ° | ° | ° | 1 | 1 |
| ✔ | ° | X | ° | ° | ° | X | 1 | 1 |
| ✔ | ° | X | ° | ° | ° | X | 1 | 1 |
| ✔ | ° | X | ° | ° | ° | X | 1 | 1 |
| ✔ | ° | X | ° | ° | ° | X | 1 | 1 |
| ✔ | ° | X | ° | ° | ° | X | 1 | 1 |
| ✔ | ° | X | ° | ° | ° | X | 1 | 1 |
| ✔ | ° | X | ° | ° | ° | X | 1 | 1 |
X: criterion not met; ✓: criterion met; o: no value recorded, either because the liver had not been weighed (for the lactate) or no bile was produced (for the bile parameters).
Livers in the first row met all our previously published criteria; those in the second row met them all, even though only one of the two bile glucose conditions was met. Note weight-adjusted lactate was not met if the liver was not weighed. The other livers not meeting the initial criteria, but where a large proportion of livers were transplanted, were perfusions requiring >30mls supplementary bicarbonate.

|     | ✓  | ✓  | ✓  | ✓  | X  | X  | 2  |
|-----|----|----|----|----|----|----|----|
| X   | ✓  | ✓  | ✓  | ✓  | X  | ✓  | 1  |
| X   | ✓  | ✓  | X  | ✓  | X  | ✓  | 2  |
| X   | ✓  | ✓  | X  | ✓  | X  | ✓  | 2  |
| X   | o  | ✓  | ✓  | ✓  | ✓  | ✓  | 1  |
| X   | o  | ✓  | ✓  | o  | o  | o  | 1  |
| X   | o  | ✓  | ✓  | X  | ✓  | ✓  | 1  |
| X   | o  | ✓  | X  | ✓  | X  | ✓  | 1  |
| X   | o  | X  | ✓  | ✓  | ✓  | X  | 1  |
| X   | X  | ✓  | ✓  | X  | X  | X  | 1  |
| X   | x  | ✓  | ✓  | X  | X  | X  | 1  |
| X   | x  | ✓  | x  | o  | o  | o  | 1  |
| X   | x  | o  | ✓  | ✓  | ✓  | ✓  | 1  |
| X   | x  | x  | x  | ✓  | o  | ✓  | 1  |
| X   | x  | x  | x  | o  | o  | o  | 2  |
Table S4  Distributions of liver donor and perfusion parameters in transplanted livers (n=154) and non-transplanted livers (n=49)

| Variable                          | Transplanted livers (n=154) | Non-Transplanted livers (n=49) | Kruskal-Wallis p-value for difference |
|-----------------------------------|-----------------------------|--------------------------------|----------------------------------------|
|                                  | N (%) Observed | Median (IQR) | Range | N (%) Observed | Median (IQR) | Range |                        |
| Additional bicarb 0-2 hours       | 154 (100)       | 20 (10, 30)  | 0, 60 | 49 (100)       | 30 (20, 40)  | 0, 70 | <0.001                  |
| Additional bicarb 0-4 hours       | 154 (100)       | 20 (10, 30)  | 0, 60 | 48 (98)        | 30 (20, 45)  | 0, 70 | <0.001                  |
| Additional bicarb 2-4 hours       | 154 (100)       | 0 (0, 0)     | 0, 15 | 49 (100)       | 0 (0, 0)     | 0, 10 | <0.005                  |
| Withdrawal period                 | 153 (99.4)      | 0 (0, 13)    | 0, 181| 49 (100)       | 10 (6, 18)   | 0, 64 | <0.007                  |
| ALT at 1 hour                     | 154 (100)       | 20 (10, 30)  | 0, 60 | 49 (100)       | 30 (20, 40)  | 0, 70 | <0.001                  |
| Log(ALT at 1 hour)                | 145 (94.2)      | 1228 (643, 2036) | 94, 8000 | 40 (81.6)       | 4240.5 (1856, 10873.5) | 282, 28823 | <0.001                  |
| ALT at 2 hours                    | 153 (99.6)      | 1484 (751, 2314) | 111, 10439 | 36 (73.5)       | 4295.5 (2325, 6842) | 328, 20599 | <0.001                  |
| Log(ALT at 2 hours)               | 138 (89.6)      | 7.3 (6.6, 7.75) | 4.71, 9.25 | 36 (73.5)       | 8.37 (7.75, 8.83) | 5.79, 9.93 | <0.001                  |
| Asystolic period                  | 154 (100)       | 9 (0, 13)    | 0, 32 | 49 (100)       | 12 (9, 14)   | 0, 22 | 0.002                   |
| Bile perfusate glucose peak       | 154 (100)       | 11.8 (8.68, 16.5) | -7.6, 29.02 | 42 (85.7)       | 5.85 (4, 10.1) | -1.6, 26.8 | <0.001                  |
| Bile glucose lowest               | 154 (100)       | 1.1 (0.9, 2.3) | 0.1, 17.8 | 41 (83.7)       | 6.9 (3, 12.3) | 0.5, 25 | <0.001                  |
| Bile peak pH                      | 149 (96.8)      | 7.8 (7.69, 7.8) | 7.38, 7.8 | 42 (85.7)       | 7.71 (7.61, 7.8) | 7.14, 7.8 | 0.018                   |
| Bile volume at 2 hours            | 140 (90.9)      | 6.45 (0.2, 11.8) | 0, 42.4 | 47 (95.9)       | 2 (0, 7.5)   | 0, 20.9 | 0.023                   |
| Bile volume at 3 hours            | 127 (82.5)      | 14.9 (4.4, 22.6) | 0, 69.9 | 40 (81.6)       | 5.65 (0.5, 13.05) | 0, 31.4 | 0.002                   |
| Bile volume at 4 hours            | 130 (84.4)      | 20.35 (9, 31) | 0.885 | 36 (73.5)       | 11 (5.6, 19.1) | 0, 46.4 | 0.017                   |
| Cold ischaemia time               | 154 (100)       | 406 (345, 497) | 91, 1001 | 49 (100)       | 444 (362, 492) | 121, 719 | 0.400                   |
| Donor age                         | 154 (100)       | 48 (30, 57)  | 10, 78 | 49 (100)       | 52.4 (38.1, 59) | 18.7, 69.5 | 0.210                   |
| EsLiP duration                    | 154 (100)       | 483.5 (389, 585) | 123, 1238 | 48 (98)        | 351.5 (256, 445) | 121, 3644 | <0.001                  |
| Glucose rate of fall              | 150 (97.4)      | 3.68 (2.51, 5) | -4.93, 22.57 | 45 (91.8)       | 2.66 (1.12, 3.87) | -3.21, 12.6 | <0.001                  |
| Lactate at 1 hour                 | 152 (98.7)      | 1 (0.4, 2.8)  | 0.1, 12.5 | 47 (95.9)       | 5.4 (1.2, 8.3) | 0.1, 18.1 | <0.001                  |
| Lactate at 2 hours                | 150 (97.4)      | 0.6 (0.3, 1.3) | 0.1, 4.5 | 47 (95.9)       | 1 (0.6, 2.5)  | 0.1, 12.3 | 0.005                   |
| Lactate at 3 hours                | 147 (95.5)      | 0.7 (0.4, 1.3) | 0.1, 16 | 45 (91.8)       | 1.1 (0.6, 2.4) | 0.1, 11.3 | 0.010                   |
| Lactate at 4 hours                | 144 (93.5)      | 0.6 (0.3, 1.2) | 0.1, 17 | 39 (79.6)       | 0.9 (0.5, 2.2) | 0.1, 4.5 | 0.009                   |
| Lactate Peak rate fall in first hour | 153 (99.4) | 17.5 (12.9, 22.4) | 3.4, 55.3 | 49 (100)       | 12 (8.5, 16.5) | 2.6, 23 | <0.001                  |
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| Variable                              | Transplanted livers (n=154) | Non-Transplanted livers (n=49) | Kruskal-Wallis p-value for difference |
|---------------------------------------|-----------------------------|-------------------------------|--------------------------------------|
|                                       | N (%) Observed | Median (IQR) | Range       | N (%) Observed | Median (IQR) | Range       |                                        |
| Log (Lactate Peak rate fall in first hour) | 153 (99.4) | 2.86 (2.56, 3.11) | 1.22, 4.01 | 49 (100) | 2.48 (2.14, 2.8) | 0.96, 3.14 | <0.001 |
| Liver weight                          | 122 (79.2) | 1543 (1332, 1800) | 614, 2800 | 37 (75.5) | 1755 (1535, 1982) | 1016, 2240 | 0.020 |
| UKDLI                                 | 154 (100) | 1.43 (1.05, 1.86) | 0.64, 2.79 | 49 (100) | 1.84 (1.44, 2.13) | 0.95, 2.6 | <0.001 |
| Feng DRI                              | 154 (100) | 2.03 (1.66, 2.44) | 1.06, 3.57 | 3 (6.1) | 2.72 (2.41, 3.15) | 2.41, 3.15 | 0.033 |
Table S5. Spearman correlation coefficients of machine perfusion variables versus the MEAF Score

| Variable                                           | MEAF score reported (N=150) | N (%) Observed | Spearman correlation coefficient with MEAF |
|----------------------------------------------------|-----------------------------|----------------|------------------------------------------|
| **Machine perfusion variables**                    |                             |                |                                          |
| ALT at 1 hour                                      |                             | 141 (94)       | 0.40962                                  |
| ALT at 2 hours                                     |                             | 135 (90)       | 0.42203                                  |
| Glucose rate of fall                               |                             | 146 (97.3)     | -0.12901                                 |
| Additional bicarb 0-2 hours                         |                             | 150 (100)      | 0.02028                                  |
| Additional bicarb 0-4 hours                         |                             | 150 (100)      | 0.04331                                  |
| Additional bicarb 2-4 hours                         |                             | 150 (100)      | -0.01336                                 |
| Lactate at 1 hour                                  |                             | 148 (98.7)     | 0.19911                                  |
| Lactate at 2 hours                                 |                             | 146 (97.3)     | 0.26093                                  |
| Lactate at 3 hours                                 |                             | 143 (95.3)     | 0.27738                                  |
| Lactate at 4 hours                                 |                             | 141 (94)       | 0.26324                                  |
| Lactate Peak rate fall in first hour               |                             | 149 (99.3)     | -0.05612                                 |
| Bile volume at 2 hours                             |                             | 136 (90.7)     | -0.23362                                 |
| Bile volume at 3 hours                             |                             | 123 (82)       | -0.24668                                 |
| Bile volume at 4 hours                             |                             | 126 (84)       | -0.27714                                 |
| Bile perfusate glucose peak difference             |                             | 144 (96)       | -0.07523                                 |
| Bile glucose lowest                                |                             | 144 (96)       | 0.27303                                  |
| Bile peak pH                                       |                             | 145 (96.7)     | 0.13184                                  |
| **Other continuous variables**                     |                             |                |                                          |
| Agonal phase                                       |                             | 149 (99.3)     | -0.00978                                 |
| Asystolic time                                     |                             | 150 (100)      | 0.03252                                  |
| Cold ischaemia time                                |                             | 150 (100)      | 0.08747                                  |
| Donor age                                          |                             | 150 (100)      | 0.21948                                  |
| EsLiP duration                                     |                             | 150 (100)      | 0.02835                                  |
| Liver weight                                       |                             | 120 (80)       | 0.23709                                  |
| UKDLI                                              |                             | 150 (100)      | 0.06020                                  |
| Feng DRI                                           |                             | 150 (100)      | 0.11900                                  |
| creatinine ratio of peak to baseline               |                             | 149 (99.3)     | 0.28522                                  |
| ESLIP to implant                                   |                             | 150 (100)      | 0.12763                                  |
| UKELD                                              |                             | 150 (100)      | 0.05098                                  |
| MELD                                               |                             | 150 (100)      | -0.03457                                 |
| MELD Na                                            |                             | 150 (100)      | 0.03470                                  |
| Preservation time                                  |                             | 150 (100)      | 0.02964                                  |
| Recipient age                                      |                             | 150 (100)      | -0.04045                                 |
Table S6. Mean difference in square-root-transformed MEAF score associated with the non-perfusion related variables included in the dataset in univariable linear regression models

| Variable                                | Level | N   | Mean diff       | 95% confidence interval | P-value | Overall p-value |
|-----------------------------------------|-------|-----|-----------------|--------------------------|---------|-----------------|
| Agonal phase                            | Linear| 149 | 0.000015        | (-0.0041, 0.0042)        | 0.990   | 0.990           |
| Asystolic time                          | Linear| 150 | 0.0030          | (-0.0084, 0.015)         | 0.600   | 0.600           |
| Cold ischaemia time                     | Linear| 150 | 0.00026         | (-0.00037, 0.0009)       | 0.420   | 0.420           |
| Donor age                               | Linear| 150 | 0.0077          | (0.0026, 0.013)          | 0.003   | 0.003           |
| EsLiP duration                          | Linear| 150 | -0.000082       | (-0.00056, 0.00039)      | 0.730   | 0.730           |
| Liver weight                            | Linear| 120 | 0.00038         | (0.00014, 0.00062)       | 0.002   | 0.002           |
| UK DLI                                  | Linear| 150 | 0.035           | (-0.12, 0.20)            | 0.660   | 0.660           |
| US DRI                                  | Linear| 150 | 0.088           | (-0.073, 0.25)           | 0.280   | 0.280           |
| creatinine ratio of peak to baseline    | Linear| 149 | 0.18            | (0.081, 0.27)            | <0.001  | <0.001          |
| ESLiP to implant                        | Linear| 150 | 0.0038          | (-0.00072, 0.0083)       | 0.098   | 0.098           |
| UKELD                                  | Linear| 150 | 0.0041          | (-0.011, 0.019)          | 0.590   | 0.590           |
| MELD                                   | Linear| 150 | 0.0074          | (-0.0062, 0.021)         | 0.280   | 0.280           |
| MELD Na                                 | Linear| 150 | 0.0037          | (-0.0089, 0.016)         | 0.560   | 0.560           |
| Preservation time                       | Linear| 150 | 0.000073        | (-0.00032, 0.00047)      | 0.720   | 0.720           |
| Recipient age                           | Linear| 150 | -0.0034         | (-0.011, 0.0038)         | 0.350   | 0.350           |
| Donor type                              |       |     |                 |                          |         |                 |
| DBD                                     |       | 68  | 0               | -                        | 0.770   |                 |
| DCD                                     |       | 82  | -0.025          | (-0.20, 0.15)            | 0.770   |                 |
| Donor type                              |       |     |                 |                          |         |                 |
| NRP utilised?                           | No    | 133 | 0               | -                        | -       | 0.016           |
|                                        | Yes   | 17  | 0.32            | (0.06, 0.59)             | 0.016   |                 |
| Super-urgent patient                    | No    | 143 | 0               | -                        | -       | 0.840           |
|                                        | Yes   | 7   | -0.040          | (-0.44, 0.36)            | 0.840   |                 |
| Liver graft number                      |       |     |                 |                          |         |                 |
| 1                                       | 138  |     | 0               | -                        | -       | 0.810           |
| 2                                       | 10   |     | 0.090           | (-0.25, 0.43)            | 0.600   |                 |
| 3                                       | 1    |     | 0.17            | (-0.88, 1.22)            | 0.750   |                 |
| 4                                       | 1    |     | -0.40           | (-1.45, 0.65)            | 0.450   |                 |
| Liver transplant                        | First | 138 | 0               | -                        | -       | 0.730           |
|                                        | Retx  | 12  | 0.056           | (-0.26, 0.37)            | 0.730   |                 |
Table S7. Distributions of candidate machine perfusion variables and the MEAF score in the full dataset (n= 150) and for livers with complete data on all candidate variables as well as the MEAF (n = 108)

| Variable                              | Full dataset (n=150) | Complete Case (n=108) |
|---------------------------------------|----------------------|-----------------------|
|                                       | N (%) Observed       | Median (IQR) or N(%)  | Median (IQR) or N (%) |
| MEAF Score:                           |                      |                      |
| Linear                                | 150 (100)            | 3.8 (2.7, 5.4)       | 3.7 (2.55, 5.4)      |
| Logged                                | 150 (100)            | 1.34 (0.99, 1.69)    | 1.31 (0.94, 1.69)    |
| Square root                           | 150 (100)            | 1.95 (1.64, 2.32)    | 1.92 (1.6, 2.32)     |
| ALT at 1 hour:                        |                      |                      |
| Linear                                | 141 (94)             | 1206 (612, 1982)     | 1217 (595, 1978)     |
| Logged                                | 141 (94)             | 7.1 (6.42, 7.59)     | 7.1 (6.39, 7.59)     |
| ALT at 2 hours:                       |                      |                      |
| Linear                                | 135 (90)             | 1459 (695, 2314)     | 1352.5 (681.5, 2150) |
| Logged                                | 135 (90)             | 7.29 (6.54, 7.75)    | 7.21 (6.52, 7.67)    |
| Glucose rate of fall:                 |                      |                      |
| Linear                                | 146 (97)             | 3.64 (2.51, 5)       | 3.99 (2.76, 5.17)    |
| Additional bicarb 0-2 hours:          |                      |                      |
| Linear                                | 150 (100)            | 20 (10, 30)          | 20 (12.5, 30)        |
| Logged                                | 150 (100)            | 20 (10, 30)          | 20 (12.5, 30)        |
| Additional bicarb 0-2 hours (proportion of cohort): | | |
| >=30                                  | 45 (30)              | 40 (37)              |                      |
| Additional bicarb 0-4 hours:          |                      |                      |
| Linear                                | 150 (100)            | 20 (10, 30)          | 20 (12.5, 30)        |
| Logged                                | 150 (100)            | 20 (10, 30)          | 20 (12.5, 30)        |
| Additional bicarb 0-4 hours (proportion of cohort): | | |
| 0-10                                  | 44 (29.3)            | 27 (25)              |                      |
| 11-29                                 | 60 (40)              | 41 (38)              |                      |
| Additional bicarb 2-4 hours:          |                      |                      |
| Linear                                | 150 (100)            | 0 (0, 0)             | 0 (0, 0)             |
| Additional bicarb 2-4 hours (proportion of cohort): | | |
| 0                                     | 145 (96.7)           | 104 (96.3)           |                      |
| Lactate at 1 hour:                    |                      |                      |
| Linear                                | 146 (97)             | 0.6 (0.3, 1.3)       | 0.6 (0.2, 1.35)      |
| Lactate at 1 hour <1 (proportion of cohort): | | |
| No                                    | 74 (49.3)            | 57 (52.8)            |                      |
| Yes                                   | 74 (49.3)            | 51 (47.2)            |                      |
| Unknown                               | 2 (1.3)              | 0                    |                      |
| Lactate at 2 hours:                   |                      |                      |
| Linear                                | 146 (97)             | 0.6 (0.3, 1.3)       | 0.6 (0.3, 1.2)       |
| Lactate at 2 hour <1 (proportion of cohort): | | |
| No                                    | 50 (33.3)            | 36 (33.3)            |                      |
| Yes                                   | 96 (64)              | 72 (66.7)            |                      |
| Unknown                               | 4 (2.7)              | 0                    |                      |
| Lactate at 3 hours:                   |                      |                      |
| Linear                                | 143 (95)             | 0.7 (0.3, 1.3)       | 0.6 (0.3, 1.2)       |
| Lactate at 3 hour <1 (proportion of cohort): | | |
| No                                    | 49 (32.7)            | 34 (31.5)            |                      |
| Yes                                   | 94 (62.7)            | 74 (68.5)            |                      |
| Unknown                               | 7 (4.7)              | 0                    |                      |
| Lactate at 4 hours:                   |                      |                      |
| Linear                                | 141 (94)             | 0.6 (0.3, 1.2)       | 0.6 (0.3, 1.1)       |
| Lactate at 4 hour <1 (proportion of cohort): | | |
| No                                    | 47 (31.3)            | 35 (32.4)            |                      |
| Yes                                   | 94 (62.7)            | 73 (67.6)            |                      |
| Unknown                               | 9 (6)                | 0                    |                      |
| Bile peak rate fall in first hour:    |                      |                      |
| Linear                                | 149 (99)             | 17.6 (13.1, 22.5)    | 18 (13.65, 22.75)    |
| Logged                                | 149 (99)             | 2.87 (2.57, 3.11)    | 2.89 (2.61, 3.12)    |
| Bile volume at 2 hours:               |                      |                      |
| Linear                                | 136 (91)             | 5.85 (0.2, 11.18)    | 7.25 (1.35, 12.85)   |
| Bile volume at 3 hours:               |                      |                      |
| Linear                                | 123 (82)             | 14.8 (4.4, 22.6)     | 15 (5.1, 23.2)       |
| Bile volume at 4 hours:               |                      |                      |
| Linear                                | 126 (84)             | 19.2 (7.95, 31)      | 24.05 (11.7, 31.85)  |
| Bile perfusate glucose peak difference|                      |                      |
| Linear                                | 144 (96)             | 11.8 (8.68, 16.5)    | 12.73 (9.85, 17.6)   |
| Bile glucose lowest:                  |                      |                      |
| Linear                                | 144 (96)             | 1.1 (0.95, 2.2)      | 1.1 (0.9, 1.7)       |
| Bile peak pH                          |                      |                      |
| Linear                                | 145 (97)             | 7.79 (7.69, 7.8)     | 7.8 (7.71, 7.8)      |
### Table S8. Distributions of other variables in full and complete candidate variable cohort

| Variable                              | Full dataset (n=150) | Complete Case (n=108) |
|---------------------------------------|----------------------|-----------------------|
|                                       | N (%) Observed       | Median (IQR) or N(%)  | N (%) Observed       | Median (IQR) or N(%)  |
| Agonal phase Linear                   | 149 (99)             | 5 (0, 13)             | 107 (99)             | 7 (0, 14)             |
| Asystolic time Linear                 | 150 (100)            | 9 (0, 13)             | 108 (100)            | 9.5 (0, 13)           |
| Cold ischaemia time Linear            | 150 (100)            | 405.5 (343, 493)      | 108 (100)            | 411 (345, 489)        |
| Donor age Linear                      | 150 (100)            | 48 (30, 56)           | 108 (100)            | 46.2 (29.95, 55.75)   |
| EsLiP duration Linear                 | 150 (100)            | 479.5 (389, 582)      | 108 (100)            | 502 (421, 594.5)      |
| Liver weight Linear                   | 120 (80)             | 1547 (1331, 1803.5)   | 97 (90)              | 1552 (1340, 1770)     |
| UK DLI Linear                         | 150 (100)            | 1.43 (1.05, 1.85)     | 108 (100)            | 1.49 (1.04, 1.86)     |
| US DRI Linear                         | 150 (100)            | 2.03 (1.66, 2.41)     | 108 (100)            | 2.03 (1.67, 2.38)     |
| creatinine ratio of peak to baseline  | 149 (99)             | 1.5 (1, 2, 2.1)       | 107 (99)             | 1.5 (1, 2, 2.1)       |
| ESLiP to implant Linear               | 150 (100)            | 71 (59, 81)           | 108 (100)            | 73.5 (61, 84)         |
| UKELD Linear                          | 150 (100)            | 53.9 (51.1, 56.4)     | 108 (100)            | 54.1 (51.2, 59.25)    |
| MELD Linear                           | 150 (100)            | 13.9 (11.1, 18.5)     | 108 (100)            | 14 (11.4, 18.7)       |
| MELD Na Linear                        | 150 (100)            | 16.9 (12.9, 21.5)     | 108 (100)            | 17.1 (12.85, 23)      |
| Preservation time Linear              | 150 (100)            | 965 (837, 1101)       | 108 (100)            | 1006 (899, 1139.5)    |
| Recipient age Linear                  | 150 (100)            | 56 (48, 62)           | 108 (100)            | 55.85 (48.95, 62.5)   |
| Donor type DBD                        | 68 (45.3)            | 47 (43.5)             | 61 (56.5)            | 47 (43.5)             |
| DCD                                   | 82 (54.7)            | 95 (88)               | 13 (12)              | 6 (5.6)               |
| NRP utilised? No                     | 133 (88.7)           | 17 (11.3)             | 95 (88)              | 13 (12)               |
| Yes                                   | 143 (95.3)           | 102 (94.4)            | 6 (5.6)              | 6 (5.6)               |
| Super-urgent patient                  | 7 (4.7)              | 100 (92.6)            | 100 (92.6)           | 100 (92.6)            |
| Liver graft number                    | 138 (92)             | 10 (6.7)              | 1 (0.7)              | 1 (0.7)               |
| 1                                     | 138 (92)             | 100 (92.6)            | 100 (92.6)           | 100 (92.6)            |
| 2                                     | 10 (6.7)             | 7 (6.5)               | 1 (0.7)              | 0 (0)                 |
| 3                                     | 1 (0.7)              | 1 (0.9)               | 1 (0.9)              | 1 (0.9)               |
| 4                                     | 1 (0.7)              | 0 (0)                 | 0 (0)                | 0 (0)                 |
| Liver transplant                      | First                | 138 (92)              | 100 (92.6)           | 100 (92.6)            |
| Retx                                  | 12 (8)               | 8 (7.4)               | 8 (7.4)              | 8 (7.4)               |
Table S9. Mean difference in square-root transformed MEAF score associated with each of the machine perfusion variables in univariable linear regression models

| Variable                      | Level       | N   | Mean diff | 95% confidence interval                  | P-value | Overall p-value |
|-------------------------------|-------------|-----|-----------|-----------------------------------------|---------|-----------------|
| ALT at 1 hour                 | Linear      | 141 | 0.00019   | (0.00012, 0.00027)                      | <.001   | <.001           |
|                               | Logged      | 141 | 0.27      | (0.17, 0.37)                           | <.001   | <.001           |
| ALT at 2 hours                | Linear      | 135 | 0.00014   | (0.000078, 0.00019)                    | <.001   | <.001           |
|                               | Logged      | 135 | 0.26      | (0.17, 0.36)                           | <.001   | <.001           |
| Glucose rate of fall          | Linear      | 146 | -0.024    | (-0.065, 0.017)                        | 0.250   | 0.250           |
| Additional bicarb 0-2 hours   | Linear      | 150 | 0.0022    | (-0.0041, 0.0084)                      | 0.490   | 0.490           |
|                               | 0-10        | 46  | 0         |                                        | 0.400   |                 |
|                               | >=30        | 45  | 0.034     | (-0.18, 0.25)                          | 0.760   |                 |
| Additional bicarb 0-4 hours   | Linear      | 150 | 0.0028    | (-0.0032, 0.0089)                      | 0.360   | 0.360           |
|                               | 0-10        | 44  | 0         |                                        | 0.020   |                 |
|                               | >=30        | 45  | 0.093     | (-0.12, 0.31)                          | 0.390   |                 |
| Additional bicarb 2-4 hours   | Linear      | 150 | -0.0087   | (-0.051, 0.034)                        | 0.680   | 0.680           |
| Additional bicarb 2-4 hours   | >0          | 145 | 0         |                                        | 0.630   |                 |
|                               | >=30        | 5   | -0.12     | (-0.59, 0.36)                          | 0.630   |                 |
| Lactate at 1 hour             | Linear      | 146 | 0.039     | (0.0046, 0.072)                        | 0.026   | 0.026           |
|                               | No          | 74  | 0         |                                        | 0.026   |                 |
|                               | Yes         | 74  | -0.19     | (-0.36, -0.024)                        | 0.026   |                 |
| Lactate at 2 hours            | Linear      | 146 | 0.17      | (0.069, 0.27)                          | 0.001   | 0.001           |
|                               | No          | 50  | 0         |                                        | 0.007   |                 |
|                               | Yes         | 96  | -0.25     | (-0.42, -0.067)                        | 0.007   |                 |
| Lactate at 3 hours            | Linear      | 148 | 0.068     | (0.0087, 0.13)                         | 0.025   | 0.025           |
|                               | No          | 49  | 0         |                                        | 0.008   |                 |
|                               | Yes         | 94  | -0.24     | (-0.42, -0.056)                        | 0.011   | 0.011           |
| Lactate at 4 hours            | Linear      | 141 | 0.030     | (-0.027, 0.087)                        | 0.300   | 0.300           |
|                               | No          | 47  | 0         |                                        | 0.005   |                 |
|                               | Yes         | 94  | -0.25     | (-0.44, -0.071)                        | 0.007   | 0.007           |
| Lactate at 4 hours <2         | Linear      | 129 | 0.023     | (-0.54, 0.081)                         | 0.140   | 0.140           |
|                               | No          | 12  | 0         |                                        | 0.140   | 0.140           |
|                               | Yes         | 117 | 0.016     | (-0.54, 0.22)                          | 0.410   | 0.410           |
| Lactate Peak rate fall in first hour | Linear    | 149 | -0.0055   | (-0.016, 0.0055)                      | 0.320   | 0.320           |
|                               | Logged      | 149 | -0.056    | (-0.24, 0.13)                          | 0.560   | 0.560           |
| Bile volume at 2 hours        | Linear      | 136 | -0.013    | (-0.023, -0.0034)                      | 0.009   | 0.009           |
|                               | Logged      | 136 | -0.033    | (-0.11, -0.005)                        | 0.011   | 0.011           |
| Bile volume at 3 hours        | Linear      | 123 | -0.0086   | (-0.015, -0.0019)                      | 0.012   | 0.012           |
|                               | Logged      | 123 | -0.0064   | (-0.011, -0.0015)                      | 0.011   | 0.011           |
| Bile perfusate glucose peak difference | Linear | 144 | -0.010    | (-0.025, 0.0049)                      | 0.180   | 0.180           |
|                          | Model | N | P-value | 95% Confidence Interval | P-value | P-value |
|--------------------------|-------|---|---------|-------------------------|---------|---------|
| Bile glucose lowest      | Linear| 144| 0.032   | (0.0025, 0.061)         | 0.033   | 0.033   |
| Bile peak pH             | Linear| 145| 0.73    | (-0.25, 1.72)           | 0.140   | 0.140   |
Table S10. Mean difference in the square-root of the MEAF score associated with a unit increase in each of the machine perfusion variables in univariable linear regression model

| Variable                        | Full dataset | Complete case cohort |
|---------------------------------|--------------|----------------------|
|                                 | Mean difference (95% CI) | Overall P-value | Mean difference (95% CI) | P-value |
| **Factors significant in univariable model** |              |                      |                          |         |
| ALT at 1 hour                   | 0.27 (0.17, 0.37) | <0.001               | 0.27 (0.16, 0.38)       | <0.001  |
| ALT at 2 hours                  | 0.26 (0.17, 0.36) | <0.001               | 0.27 (0.16, 0.38)       | <0.001  |
| Glucose rate of fall            | -0.024 (-0.065, 0.017) | 0.250               | -0.044 (-0.099, 0.010) | 0.110   |
| Additional bicarb 0-2 hours     | 0.0022 (-0.0041, 0.0084) | 0.490               | 0.0016 (-0.0060, 0.0092) | 0.670   |
| Additional bicarb 0-2 hours     | 0-10          | 0.400                | 0                        | 0.096   |
|                                  | 11-29         | 0.13 (-0.0716, 0.34) | -                        |        |
|                                  | >=30          | 0.034 (-0.18, 0.25)  | -                        |        |
| Additional bicarb 0-4 hours     | 0.0028 (-0.0032, 0.0089) | 0.360               | 0.0024 (-0.0048, 0.0096) | 0.520   |
| Additional bicarb 0-4 hours     | 0-10          | 0.223                | 0                        | 0.008   |
|                                  | 11-29         | 0.28 (0.073, 0.48)   | -                        |        |
|                                  | >=30          | 0.093 (-0.12, 0.31)  | -                        |        |
| Additional bicarb 2-4 hours     | -0.0087 (-0.051, 0.034) | 0.680               | 0.0081 (-0.039, 0.055)  | 0.730   |
| Additional bicarb 2-4 hours     | 0             | 0.630                | 0                        | 0.730   |
|                                  | >0            | -0.12 (-0.59, 0.36)  | -                        |        |
| Lactate at 1 hour               | 0.039 (0.0046, 0.072) | 0.026               | 0.042 (0.0020, 0.083)   | 0.040   |
| Lactate at 1 hour <1            | 0             | 0.026                | 0                        | 0.095   |
|                                  | Yes           | -0.19 (-0.36, -0.024) | -                  |        |
| Lactate at 2 hours              | 0.17 (0.069, 0.27) | 0.001               | 0.20 (0.084, 0.31)      | <0.001  |
| Lactate at 2 hour <1            | 0             | 0.007                | 0                        | 0.007   |
|                                  | Yes           | -0.25 (-0.42, -0.067) | -                  |        |
| Lactate at 3 hours              | 0.068 (0.0087, 0.13) | 0.025               | 0.065 (0.0036, 0.13)    | 0.038   |
| Lactate at 3 hour <1            | 0             | 0.011                | 0                        | 0.016   |
|                                  | Yes           | -0.24 (-0.42, -0.056) | -                  |        |
| Lactate at 4 hours              | 0.03 (-0.027, 0.087) | 0.3                 | 0.024 (-0.036, 0.083)   | 0.430   |
| Lactate at 4 hour <1            | 0             | -0.007               | 0                        | 0.030   |
|                                  | Yes           | -0.25 (-0.44, -0.071) | -                  |        |
| Lactate at 4 hour <2            | 0             | 0.140                | 0                        | 0.290   |
|                                  | Yes           | -0.23 (-0.54, 0.081)  | -                  |        |
| Lactate at 4 hour <2.5          | 0             | 0.410                | 0                        | 0.530   |
|                                  | Yes           | -0.16 (-0.54, 0.22)   | -                  |        |
| Lactate Peak rate fall in first hour | -0.0055 (-0.016, 0.0055) | 0.320               | -0.0089 (-0.023, 0.0050) | 0.210   |
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|                | Logged       | Bile volume at 2 hours     | Bile volume at 3 hours     | Bile volume at 4 hours     | Bile perfusate glucose peak difference | Bile glucose lowest | Bile peak pH       |
|----------------|--------------|----------------------------|----------------------------|----------------------------|----------------------------------------|---------------------|-------------------|
|                | -0.056 (-0.24, 0.13) | 0.560                      | -0.15 (-0.40, 0.10)        | 0.250                      |                                        |                     |                   |
| Donor type     |              |                            |                            |                            |                                        |                     |                   |
| DBD            |              |                            |                            |                            |                                        |                     |                   |
| DCD            | -0.013 (-0.023, -0.0034) | 0.009                     | -0.0093 (-0.021, 0.0021)   | 0.110                      |                                        |                     |                   |
| Donor age      | Linear       | -0.0086 (-0.015, -0.0019) | 0.012                      | -0.0070 (-0.014, 0.00024)  | 0.058                                  |                     |                   |
| UKDLI          | Linear       | -0.0064 (-0.011, -0.0015) | 0.011                      | -0.0057 (-0.011, -0.00010) | 0.046                                  |                     |                   |
| Feng DRI       | Linear       | -0.01 (-0.025, 0.0049)    | 0.180                      | -0.0063 (-0.025, 0.013)    | 0.510                                  |                     |                   |
| Bile perfusate glucose peak difference | Linear       | 0.032 (0.0025, 0.061)     | 0.033                      | 0.055 (-0.0006, 0.11)      | 0.050                                  |                     |                   |
| Bile glucose lowest | Linear       | 0.73 (-0.25, 1.72)      | 0.140                      | 1.09 (-0.086, 2.27)        | 0.069                                  |                     |                   |
| Bile peak pH   | Linear       | 0.088 (-0.073, 0.25)     | 0.280                      | 0.070 (-0.12, 0.26)        | 0.470                                  |                     |                   |
|                |              | 0.036 (-0.030, 0.01)     | -0.063 (-0.27, 0.14)       | -0.001 (-0.27, 0.17)       | -0.0004                                |                     |                   |
| Donor age      | Linear       | 0.0077 (0.0026, 0.013)   | 0.004                      | 0.0093 (0.0030, 0.016)     | 0.0004                                |                     |                   |
| Feng DRI       | Linear       | 0.035 (-0.12, 0.20)      | 0.660                      | 0.023 (-0.16, 0.21)        | 0.0810                                |                     |                   |
| UKDLI          | Linear       | 0.088 (-0.073, 0.25)     | 0.280                      | 0.070 (-0.12, 0.26)        | 0.470                                  |                     |                   |
Figure S1. Graft, patient and transplant survival

Graft survival is censored for patient death; transplant survival is graft survival not censored for patient death.

One year graft survival was 95.4%, patient survival 94%, and transplant survival 91.2%.
Figure S2a. Frequency distribution of the model for early allograft function (MEAF) scores for transplanted livers

Figure S2b. Frequency distribution of the square root transformed Model for Early Allograft Function (MEAF) scores for transplanted livers
**Figure S2a:** Frequency distribution of 2-hour perfusate ALT concentrations in transplanted and non-transplanted livers

**Figure S2b:** Frequency distribution of the natural logarithm of the 2-hour perfusate ALT concentrations in transplanted and non-transplanted livers
Figure S3. Frequency distribution of the 2-hour perfusate lactate concentration (mmol/L)
Figure S4. Frequency distribution of the number of millimoles of sodium bicarbonate supplementation required in the first 4 hours of perfusion to keep the perfusate pH >7.2, comparing transplanted and non-transplanted livers.
Figure S5. Frequency distribution of the highest recorded bile pH (note values >7.8 default to 7.8)
Figure S6: Frequency distribution of the lowest recorded bile glucose, comparing transplanted and non-transplanted livers.

Figure S7: Frequency distribution of the largest difference between perfusate minus bile glucose concentrations (in mmol/L), comparing transplanted and non-transplanted livers.
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Figure S8 (a to q): shows the scatter plots and Spearman correlation coefficients for machine perfusion variables with the MEAF score.
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- Bile perfusate glucose peak difference
  - Spearman correlation: -0.075

- Bile glucose lowest
  - Spearman correlation: 0.273

- Bile peak pH
  - Spearman correlation: 0.131