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Effects of intensive blood glucose control on surgical site infection for liver transplant recipients: A randomized controlled trial

Oliveira R, Tanner J, de Brito Poveda V

ASBTRACT

Background: The evidence supporting intensive blood glucose control to prevent surgical site infections (SSIs) among liver transplant (LT) recipients is insufficient.

Aim: To assess the effects of post-operative intensive blood glucose control (IBGC) against standard blood glucose control (SBGC) on the incidence of SSIs among adult LT recipients.

Methods: A randomized controlled trial (ClinicalTrials.gov identifier NCT03474666). The IBGC target was 80 to 130 mg/dL and the SBGC target was below 180 mg/dL. Analyses were made on an intention-to-treat basis.

Results: Of the 41 recipients enrolled onto the trial, 20 were randomly allocated to the IBGC group and 21 to the SBGC group. There were no significant differences in SSIs among recipients allocated to either group (RR 0.78, 95% CI 0.21-2.88; P=0.69). Mean blood glucose levels were significantly lower in the IBGC group in the 24 hour period after surgery (145.0± 20.7 mg/dL and 230.2±51.6 mg/dL; P=0.001). While there were fewer episodes of hypoglycaemia in the IBGC group this did not reach statistical significance. There were no episodes of severe hypoglycaemia in either group. Hyperglycaemia and severe hyperglycaemia were significantly more frequent in the SBGC group (RR 0.70, 95% CI 0.52-0.93; P=0.001 and RR 0.07, 95% CI 0.01-0.48; P=0.001, respectively). Length of hospital stay was significantly shorter for recipients in the IBGC group (13.1±5.5 vs 19.3±12.1; P= 0.04).

Conclusions: Although this small trial did not find intensive control reduced SSI, it was associated with lower blood glucose levels, fewer episodes of hyperglycaemia and severe hyperglycaemia, and shorter length of hospital stay.

KEYWORDS: Blood Glucose; Hyperglycemia; Liver Transplantation; Surgical Wound Infection; Controlled Clinical Trial; Nursing.

Background

Surgical Site Infections (SSIs) are one of the most frequently occurring healthcare-associated infections (HCAIs) and are an important infectious complication following liver transplant [1-2]. Deceased donor liver transplant recipients are among the highest patient groups for developing an SSI with an incidence of 9.6% to 35.5% [3]. The consequences of developing an SSI for this group of patients are severe with liver transplant recipients being twice as likely to suffer graft loss or death, spending up to 24 additional days in hospital, having higher re-admission rates and costing up to an additional 130,000 USD [2,4-6].

Hyperglycaemia is one of the risk factors for SSI and is common among liver transplant recipients with an incidence of up to 94% in the first few hours following liver transplant [7,8]. Liver transplant recipients with hyperglycaemia are three times more likely to develop an SSI than normoglycemic recipients [7-10].

Hyperglycaemia can be prevented through blood glucose control, though the level of control has not been determined. Studies comparing intensive blood glucose protocols (glucose levels lower than 140 mg/dL) with standard protocols (glucose levels higher than 180 mg/dL) have found a reduction in SSIs [11, 12]. However, these studies involve patients having cardiac surgery or trauma surgery and the findings may not be applicable to liver transplant recipients. Liver transplant recipients present different challenges from most other

surgical patient groups as they commence immunosuppression therapy at the start of the intraoperative period and have longer than standard operation duration times (up to around 8 hours) [8].

A recent literature review highlighted the lack of prospective studies evaluating the outcome of intensive blood glucose control among liver transplant recipients on SSI incidence and called for more high quality trials on this topic [13]. This paper describes a clinical randomized trial designed to test the hypothesis that post-operative intensive blood glucose control reduces the incidence of SSI among liver transplant recipients.

Material and methods

Design and Setting

This randomized controlled trial, compares two blood glucose control protocols beginning at the post-operative admission to the Intensive Care Unit (ICU). The primary outcome, SSI, was assessed at 30 days. Secondary outcomes were blood glucose levels, length of stay and death. The study was conducted in a Brazilian teaching referral hospital. Participant enrolment took place between March 2018 and October 2019, with data collection continuing until January 2020. Ethical approval was obtained by the relevant Institutional Review Board. Participants were allowed to withdraw at any time, and anonymity, privacy, confidentiality and data protection were maintained throughout the study. The study is registered at ClinicalTrials.gov (NCT03474666). CONSORT reporting guidelines were followed.

Population

Since 2009, 342 liver transplants were performed at the selected centre. The recipients' mean age was 55.5 years (Standard Deviation (SD)10.1 years), 253 (73.9%) were male. The mean body index was 27.4 kg/m2 (4.66 kg/m^2) with Cirrhosis due to chronic hepatitis C as the

primary cause leading to liver transplant (111 recipients; 32.4%) and the mean of Model of End-stage Liver Disease (MELD) score was 17.8 (SD7.0). The 1-year survival rate is around 87% on the entire cohort.

Participants

All liver transplant candidates attending pre-operative patient assessment during the study recruitment dates who met the inclusion and exclusion criteria were invited to take part in the study and informed consents were given. Inclusion criteria were 18 years of age or older and receiving a liver transplant from a deceased donor. Exclusion criteria were any previous surgery in the 30 days before the liver transplant.

Sample size

The sample size was calculated based upon a good quality study of 777 liver transplant patients where the SSI rate was found to be 38% [2]. Fifty-eight recipients were needed to have an 80% chance of detecting, as significant at the 5% level, a decrease in SSI from 40% in the standard control group to 10% in the intensive control group. Thus, the sample would need 29 recipients allocated to each group.

Randomization and allocation

A computer generated random numbers table was used to allocate recipients to one of the two groups in a 1:1 ratio. Group allocations were placed inside sequentially numbered, sealed, opaque envelopes by an independent researcher. An independent critical care nurse opened the allocation envelope when the patient was admitted to the ICU, after the recipient had been enrolled onto the study.

Blinding

Patients were unaware of their group allocation status. ICU nursing staff who provided routine care and delivered insulin as per study protocol were aware of the

recipients' allocation status. The panel which assessed SSI outcomes was blinded and the researcher who collated secondary outcome data was aware of allocation status.

Interventions

Recipients were randomised to either intensive blood glucose control or standard blood glucose control protocols.

Intensive blood glucose control group (IBGC)

The intensive blood glucose control protocol was used in a previous study [7]. Continuous intravenous human regular insulin infusion with a targeted blood glucose level set between 80-130 mg/dL was initiated after surgery on admission to the ICU. The protocol was discontinued after 24 hours or earlier if recipients resumed at least 50% of their intake orally or through tube feeding. When the trial intervention discontinued recipients received the standard glucose control protocol routinely implemented in the hospital for liver transplant recipients.

Standard blood glucose control group (SBGC)

The standard blood glucose control protocol was the standard protocol routinely employed within the participating hospital. A sliding scale of subcutaneous human regular insulin for a given blood glucose reading, with a targeted blood glucose level set at <180 mg/dL, was initiated on admission to the ICU and continued until the recipients' discharge from hospital. This range is recommended by the Centers for Diseases Control and Prevention (CDC) [1].

Blood glucose measurement

Blood glucose levels were read hourly for the first 48 hours. If patients were considered stable after 48 hours, readings were reduced to four times a day continuing until discharge from hospital. Blood samples were taken at the recipients' bedside using a capillary blood sample with a calibrated finger prick device (Abbot FreeStyle Precision Pro®, Witney,

Oxon, UK). If the recipient was receiving a high dose of vasopressors, which affect peripheral perfusion, a blood sample from an arterial line was used instead. In the ICU, nurses adjusted the insulin doses, depending on the blood glucose level reading following the allocated protocol.

Outcome measurements

Primary outcome - SSI

The primary outcome was the incidence of superficial, deep or organ/space SSIs diagnosed according to the CDC criteria [14].

All wounds were followed up for 30 days. While recipients were in hospital, wound sites were photographed every second day. If recipients were discharged before 30 days, photographs were taken at the weekly outpatient clinic and a validated post discharge SSI surveillance questionnaire was completed with recipients over the telephone [15].

A wound culture swab was taken from all recipients who displayed signs or symptoms of SSI and a computed tomography scan (CT) was carried out for all recipients who presented with pus in their abdominal drain. At the end of the study, all wound data (photographs, laboratory results, surveillance questionnaires and CT scans) were assessed by a blinded adjudication panel comprising transplant clinicians or experts in SSI diagnosis.

Secondary outcomes – blood glucose levels, length of stay and death

Blood glucose levels were recorded hourly for the first 24 hour period after surgery while recipients received either the intensive or the standard glucose protocol, and also during the 'follow up' period (hours 25-48) when both groups of recipients were receiving the hospital's standard glucose control. The following definitions were used; hypoglycaemia - blood glucose level < 70 mg/dL [16], severe hypoglycaemia - blood glucose level < 40 mg/dL [9], hyperglycaemia -blood glucose level > 180 mg/dl and < 250 mg/dL [16], and severe hyperglycaemia – blood glucose level ≥ 250 mg/dL [7].

Data relating to length of ICU stay, length of post-operative hospital stay and incidences of death by any cause within 90 days following transplant were collated from recipients' Electronic Medical Records.

Statistical analysis

Analysis was based on intention-to-treat information. Categorical variables were analysed by Pearson's chi-squared test or Fisher's exact test, as appropriate. Normality was tested using the Kolmogorov-Smirnov test. Continuous variables were analysed by the Student t test for normally distributed data and the Mann-Whitney test for all other data. Variables which failed randomization and had significant differences among the groups were included in a Cox regression model based on residual analysis of the Schoenfeld test. All results are reported as Relative Risk (RR) at 95% Confidence Interval (CI). Statistical significance was set at P= 0.05. All statistical analyses were performed using IBM SPSS Statistics for Windows, version 20.0 (IBM Corp., Armonk, N.Y., USA) and STATA for Windows, version 12.0 (StataCorp., College Station, TX, USA).

Results

All eighty one liver transplant candidates who attended the pre-assessment clinic during the recruitment phase of the study consented to participate. Two candidates underwent surgery in the 30 days prior to the liver transplant and were excluded from the study. Thirty-eight liver transplant candidates who consented to take part were not offered a transplant during the study period and were unable therefore to be enrolled onto the study. Forty-one liver transplant recipients were enrolled onto the study; 20 recipients were randomised to the IBGC group and 21 to the SBGC group. All 41 recipients had initial blood glucose higher than 180 mg/dL. One recipient from each group died within 24 hours of surgery before the completion of blood glucose protocols. There were no other losses to follow-up. Data from all randomized recipients, including the incomplete data from the two recipients who died

within the first 24h, were included in the analysis (**Figure 1**). Data is reported for all outcomes specified at the outset of the study.

[Figure 1]

Baseline characteristics

Liver transplant recipients randomized to the two groups were similar for all baseline demographic, medical history and surgical characteristics. Although, while mean pre-anaesthesia blood glucose levels were similar for IBGC and SBGC groups (126.2 vs 106.95 mg/dL; P=0.27) the mean blood glucose level on admission to ICU was significantly higher among recipients allocated to the IBGC group compared to the SBGC group (222.8 vs 176.6 mg/dL; P= 0.004) (**Table 1**). Donors' characteristics by recipients' allocation group were also well matched. Although blood cultures from two donors in the SBGC group tested positive for oxacillin resistant *Staphylococcus epidermidis* and there were significantly more donors with a history of tobacco use in the SBGC group compared to the IBGC group (95.2% vs 60.0%; P=0.01)

[Table 1]

Outcomes

Surgical site infection

SSI outcome data is shown Table 2. The incidence of SSI among the entire cohort of liver transplant recipients was 19.5% (8/41 recipients). There were no significant differences in SSIs among recipients allocated to the IBGC group compared to the SBGC group (RR 0.78, 95% CI 0.21 to 2.88; P= 0.69). There was no significant difference by classification of SSI (superficial, deep, or organ space) between the two groups (P=0.35). The main microorganisms identified from all culture swabs were: *S. aureus* (3; 37.5%); *K. pneumoniae* (2; 25.0%), *E. coli* (2; 25.0%), and *E. cloacae* (1; 12.5%).

Blood glucose levels

In the initial 24 hour period after surgery the mean blood glucose level for recipients allocated to the IBGC group was significantly lower than that observed among the SBGC group, 145.0 mg/dL vs 230.2 mg/dL; P=0.001. In the follow up period, 25-48 hours, after the transplant, no significant differences were observed between the mean blood glucose levels for the IBGC and SBGC groups, 165 (SD 38.6) mg/dL and 170.6 (SD 30.0) mg/dL, respectively (P= 0.66).

There were fewer recipients in the IBGC group who presented with at least one episode of hypoglycaemia in the initial 24 hours following liver transplant compared to those allocated to the SBGC group 2 (10.0%) and 3 (14.3%), respectively (RR 0.70, 95% CI 0.13 to 3.76); P>0.99. This is not significant. Similarly, during the following 25-48 hour period, none of the recipients from the IBGC group and one recipient (4.8%) from SBGC group presented with hypoglycaemia, this is not significant (RR 7.33, 95% CI 0.60 to 88.94; P>0.99). None of the recipients assigned to either the IBGC or the SBGC group presented with severe hypoglycaemia during the 48 hours following liver transplant.

During the initial 24 hour post-operative period, there were significantly more recipients in the SBGC group with at least one episode of hyperglycaemia compared to those in the IBGC group, 21 (100.0%) and 14 (70.0%) respectively (RR 0.70, 95% CI 0.52 to 0.93; P=0.001). Even after the intensive control protocol ended at 24 hours, there continued to be more recipients allocated to the SBGC group having hyperglycaemia (18; 85.7%) compared to those in the IBGC group (9;47.4%) (RR 0.52, 95% CI 0.31 to 0.87; P=0.01). Similarly, during the initial 24 hours period, the number of recipients having at least one episode of severe hyperglycaemia was significantly greater among recipients allocated to the SBGC group compared to the IBGC group, 15 (71.4%) and 1 (5.0), respectively (RR 0.07, 95% CI 0.01 to 0.48; P=0.001) (**Table 2**).

Length of stay

Recipients in the IBGC group showed a tendency towards spending less time in the ICU compared to recipients in the SBGC group, (8.7 vs 14.3 days; P= 0.07) respectively. The mean length of postoperative hospital stay was also significantly shorter, by around 6 days, for recipients having intensive control compared to those having standard control, (13.1 days compared to 19.3 days; P=0.04) respectively. Of the recipients who developed an SSI, the mean of postoperative length of stay for those having intensive control was 15.0 days compared to those having standard control 30.8 days, this did not achieve significance (P=0.15) **(Table 2)**.

Deaths

Seven of the 41 recipients died (17.15%) by any cause within 90 days. Primary cause of death was: septic shock (4/7; 57.1%), haemorrhagic shock (1/7; 14.3%), primary allograft dysfunction (1/7; 14.3%), and ischaemic stroke (1/7;14.3%) (**Table 2**). Four recipients in the IBGC group died (20.0%) compared with three recipients in the IC group (14.3%), (RR 1.40, 95% CI 0.35 to 5.48; P=0.69). This is not significant.

There did not appear to be a relationship between SSI and deaths. Of the eight recipients who developed an SSI, three died (37.5%) and out of the 33 recipients who did not develop an SSI, four died (12.1%). This is not statistically significant (RR 3.09, 95% CI 0.85 to 11.15; P=0.08).

However, there did appear to be a significant relationship between deep incisional or organ space SSIs and deaths. Of the five recipients with a deep incisional or organ/space SSI, three died (60.0%) and out of the 33 recipients who did not develop an SSI, four (12.2%) died (RR 4.95, 95% CI 1.54 to 15.86; P=0.01).

[Table 2]

Discussion

Blood glucose control and SSI

While this trial found fewer SSIs in the IBGC group, this was not statistically significant. This is a similar finding to two other RCTs, one with 164 recipients[10] and one with 100 recipients[18] comparing blood glucose controls among liver transplant recipients. Neither of these two trials found a difference in SSI rates. As the sample sizes in the two trials plus the present trial are comparatively small it is possible that a larger study, or meta-analysis, may produce a different result. A systematic review published in 2017 including 2,836 patients having a range of surgical procedures (except transplantation surgery) showed a 57% reduction in risk of SSI among patients having intensive glycaemic control compared to those having standard control [19].

National guidelines remain cautious over recommendations. The updated Surgical Care Improvement Project recommends a blood glucose level of <180mg/dL, but only for post-operative cardiac surgery patients [20]. The World Health Organization [21] supports perioperative blood glucose control but decided not to state an optimal blood glucose level due to lack of evidence, and the CDC [1] recommends perioperative glycaemic control using target levels <200mg/dL.

Blood glucose levels, length of stay and death

Mean blood glucose levels in this study were significantly lower while recipients were receiving the intensive protocol. Wallia et al. [10] also found significantly lower blood glucose levels among recipients allocated to the intensive blood glucose control compared with the standard control in the postoperative period. However, the levels in this study were not sufficiently low to increase the risk of hypoglycaemia. While there were slightly fewer recipients in the intensive control group who presented with hypoglycaemia during 0-24 hours and 25-48 hours, this was not significant, and no recipients in either group presented with severe hypoglycaemia. Conversely, the NICE-Sugar study found an increased risk of

hypoglycaemia during hospitalisation associated with an intensive blood glucose protocol in a study which included 3,054 clinical and surgical patients [22].

This trial found recipients having intensive blood glucose control were at significantly lower risk of developing hyperglycaemia or severe hyperglycaemia during the first 24 hours while the protocols were in place. This continued in relation to hyperglycaemia during the subsequent follow up period (25-48 hrs). Hyperglycaemia and severe hyperglycaemia are associated with higher rates of allograft rejection [23], prolonged mechanical ventilation [23], and death [24].

Recipients having the intensive blood glucose control tended to spend less time in the ICU and, post-operatively, spent an average of 6 days fewer in hospital. This is not supported by either of the two trials [10,18] which compared blood glucose controls in liver transplant recipients. These trials found no difference in duration of post-operative stay. To date, it would appear that no other studies have identified blood glucose levels as a predictor of post-operative length of stay [25-27]. This warrants further investigation due to the potential cost savings.

Death did not appear to be significantly associated with blood glucose control protocols in this trial or in an earlier systematic review comprising 17,582 surgical patients [28], although an association was found between death at 90 days and allocation to an intensive blood glucose protocol in the NICE-Sugar study [22]. However, death was associated with recipients having deep or organ/space infections [29, 30]. This finding is consistent with two studies including 370 and 331 liver transplant recipients which estimated that patients who developed deep or organ/space SSIs were at higher risk of death at 30 and 90 days following transplantation [29, 30].

Strengths and limitations

This study appears to be the first RCT assessing the effects of blood glucose control on SSI as a primary outcome following liver transplantation. It benefits from using an internationally accepted definition for SSI, and SSIs were assessed by a blinded panel. Although it was not possible to extend the duration of the study in an attempt to reach full *a priori* sample size recruitment, the findings are valuable as they can contribute to a meta-analysis.

Implications for research and practice

This RCT finds the benefit of intensive glycaemic control in reducing SSIs is uncertain. However, intensive blood glucose control is shown to be associated with shorter lengths of post-operative stay, a reduced risk of hyperglycaemia, no increased risk of hypoglycaemia and no episodes of severe hypoglycaemia. Taking this into consideration, we cautiously suggest the use of intensive blood glucose control to reduce the length of stay and other complications arising from hyperglycaemia, but not as a measure to prevent SSIs among liver transplant recipients.

As we found a tendency towards reduction in SSI in the IBGC group with this trial which did not reach full recruitment, we suggest further larger RCTs comparing the effects of intensive blood glucose control against standard control following liver transplant with SSI as the primary outcome. These trials should follow CONSORT and employ a validated definition for SSI such as that given by the CDC [14].

This study was carried out in a single hospital in a middle-income country among deceased-donors liver transplant recipients. It would be interesting to see if the results were supported by a multi-centred trial in a developed country.

Conclusions

There were no significant differences in SSIs among recipients allocated to the IBGC group compared to the SBGC group. However, the study under-recruited and a larger sample may have achieved significance. Recipients having intensive blood glucose protocol presented with significantly lower levels of blood glucose and fewer episodes of hyperglycaemia, but no episodes of severe hypoglycaemia and the risk of hypoglycaemia was not increased. The length of post-operative hospital stay was significantly shorter among recipients allocated to intensive blood glucose control.

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Data Availability Statement: The database generated and analysed during the current study is available from the corresponding author.

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Table 1. Recipients' and donors' baseline characteristics.

Variable	All recipients n= 41	IBGC* n=20	SBGC† n=21	P Value
Recipients characteristics				
Age, years, mean (SD)‡	55.7 (8.9)	54.9 (9.7)	56.6 (8.4)	0.55‖‖
Female sex, n (%)	10 (24.4)	5 (25.0)	5 (23.8)	>0.99¶¶
Race, n (%)				
White	31 (75.6)	16 (80.0)	15 (71.4)	
Black	3 (7.3)	1 (5.0)	2 (9.5)	0.74***
Multiracial	7 (17.1)	3 (15.0)	4 (19.0)	
BMI§, kg/m^2, mean (SD) ‡	25.1 (4.6)	26.0 (4.0)	24.3 (5.0)	0.23‖‖
MELD‖ score before transplant, mean (SD) ‡	17.4 (6.5)	16.9 (5.3)	17.9 (7.5)	0.62‖‖
Pre-existing conditions, n (%)				
Diabetes mellitus	14 (34.1)	6 (30.0)	8 (38.1)	0.58***
Hypertension	9 (21.9)	4 (20.0)	5 (23.8)	>0.99***
Dyslipidaemias	1 (2.4)	1 (5.0)	0 (0.0)	0.48***
Previous abdominal surgery	12 (29.3)	7 (35.0)	5 (23.8)	0.43***
Pretransplant complications, n (%)				
Ascites	27 (65.9)	15 (75.0)	12 (57.1)	0.22***
Encephalopathies	29 (70.7)	14 (70.0)	15 (71.4)	0.92***
Upper gastrointestinal haemorrhage	11 (26.8)	6 (30.0)	5 (23.8)	0.65***
Hepatorenal syndrome	2 (4.9)	1 (5.0)	1 (4.8)	>0.99***
Paracentesis	15 (36.6)	9 (45.0)	6 (28.6)	0.27***
Cytomegalovirus status, n (%)				
Positive CMV¶ IgM**	1 (2.4)	1 (5.0)	0 (0.0)	0.48***
Positive CMV¶ IgG††	36 (87.8)	17 (85.0)	19 (90.5)	0.66***
Positive Hepatitis C virus, n (%)	10 (24.4)	5 (25.0)	5 (23.8)	>0.99***
Donors' characteristics by the recipients' allocation group				
Age, years, mean (SD)‡	43.9 (15.7)	44.0 (17.3)	43.8 (14.6)	0.96‖‖
Female sex, n (%)	15 (36.6)	9 (45.0)	6 (28.6)	0.27¶¶
Race, n (%)				
White	25 (61.0)	14 (70.0)	11 (52.4)	
Multiracial	10 (24.4)	5 (25.0)	5 (23.8)	0.27***
Black	6 (14.6)	1 (5.0)	5 (23.8)	
History of tobacco use, n (%)	32 (78.0)	12 (60.0)	20 (95.2)	0.01¶¶
BMI, kg/m^2, mean (SD) ‡	25.2 (4.1)	25.5 (4.7)	24.9 (3.7)	0.66‖‖
Allograft weight, g., mean (SD)‡	1,446.1 (320.2)	1,485.0 (384.2)	1,407.2 (244.4)	0.45‖‖
ICU‡‡stay, days, median (IQR)§§	4.0 (3.0 - 7.0)	5.5 (3.2 - 9.5)	4.0 (2.5 – 5.0)	0.01†††
Causa mortis, n (%)				
Cardiovascular diseases	8 (19,5)	2 (10.0)	6 (28.6)	
Cerebrovascular diseases	24 (58.5)	12 (60.0)	12 (57.1)	0.27***
External causes	9 (21.9)	6 (30.0)	3 (14.3)	
Antibiotic use, n (%)	27 (65.8)	13 (65.0)	14 (66.7)	0.91¶¶
Positive blood culture, n (%)	2 (4.9)	0 (0.0)	2 (9.5)	0.48***
Positive CMV¶ IgM**, n (%)	2 (4.9)	1 (5.0)	1 (4.8)	>0.99***
Positive CMV¶ IgG††, n (%)	37 (90.2)	19 (95.0)	18 (85.7)	0.60***

NOTES: *IBGC: Intensive blood glucose control; †SBGC: Standard blood glucose control; ‡SD: standard deviation; §BMI: Body mass index; ‖MELD: Model for end-stage liver disease; ¶CMV: cytomegalovirus; **IgM: Immunoglobulin M; ††IgG: Immunoglobulin G; ‡‡ICU: Intensive Care Unit; §§IQR: Interquartile range; ‖‖Student's t-test; ¶¶Pearson's chi-squared test; ***Fisher exact test; †††Mann-Whitney's test.

Table 2. Post-surgical outcomes.

Variable	All recipients n= 41	IBGC* n=20	SBGC† n=21	P Value
Recipients with SSI‡, n (%)	8 (19.5)	3 (15.0)	5 (23.8)	0.69¶
SSI by topography, n (%)				
Incisional superficial	3 (37.5)	0 (0.0)	3 (60.0)	
Deep incisional	3 (37.5)	2 (66.7)	1 (20.0)	0.35¶
Organ/cavity	2 (25.0)	1 (33.3)	1 (20.0)	
Blood glucose 0-24h following liver transplant, mg/dL, mean (SD)§	188.7 (58.2)	145.0 (20.7)	230.2 (51.5)	0.001**
Blood glucose 25-48h following liver transplant, mg/dL, mean (SD)§	168.0 (38.6)	165.2 (47.1)	170.6 (30.0)	0.66**
Recipients having hypoglycaemia 0-24h following liver transplant, n (%)	5 (12.2)	2 (10.0)	3 (14.3)	>0.99¶
Recipients having hypoglycaemia 25-48h following liver transplant, n (%)	1 (2.5)	-	1 (4.8)	>0.99¶
Recipients having severe hypoglycaemia 0-24h following liver transplant, n (%)	-	-	-	-
Recipients having severe hypoglycaemia 25h-48h following liver transplant, n (%)	-	-	-	-
Recipients having hyperglycaemia 0-24h following liver transplant, n (%)	35 (85.4)	14 (70.0)	21 (100.0)	0.001¶
Recipients having hyperglycaemia 25-48h following transplant, n (%)	27 (67.5)	9 (47.4)	18 (85.7)	0.001¶
Recipients having severe hyperglycaemia 0-24h following liver transplant, n (%)	16 (39.0)	1 (5.0)	15 (71.4)	0.001¶
Recipients having severe hyperglycaemia 25-48h following liver transplant, n (%)	11 (27.5)	3 (15.8)	8 (38.1)	0.11¶
Time on mechanical ventilation, hours, mean (SD)§	17,8 (12,9)	19,6 (14,7)	16,2 (11,3)	0,88**
Length of ICU‖ stay, days, mean (SD)§	11.6 (10.0)	8.7 (5.4)	14.3 (12.5)	0.07**
Length of postoperative hospital stay, days, mean (SD)§	16.3 (9.9)	13.1 (5.5)	19.3 (12.1)	0.04**
Length of postoperative hospital stay for recipients with an SSI‡, days, mean (SD)§	24.8 (17.1)	15.0 (1.0)	30.8 (19.9)	0.15**
Death to 90 days following transplant, n (%)	7 (17.1)	4 (20.0)	3 (14.3)	0.69¶

NOTES: * IBGC: Intensive blood glucose control; †SBGC: Standard blood glucose control; ‡SSI: Surgical site infection; §SD: standard deviation, ‖ICU: Intensive care unit; ¶Fisher exact test; **Student's t-test.

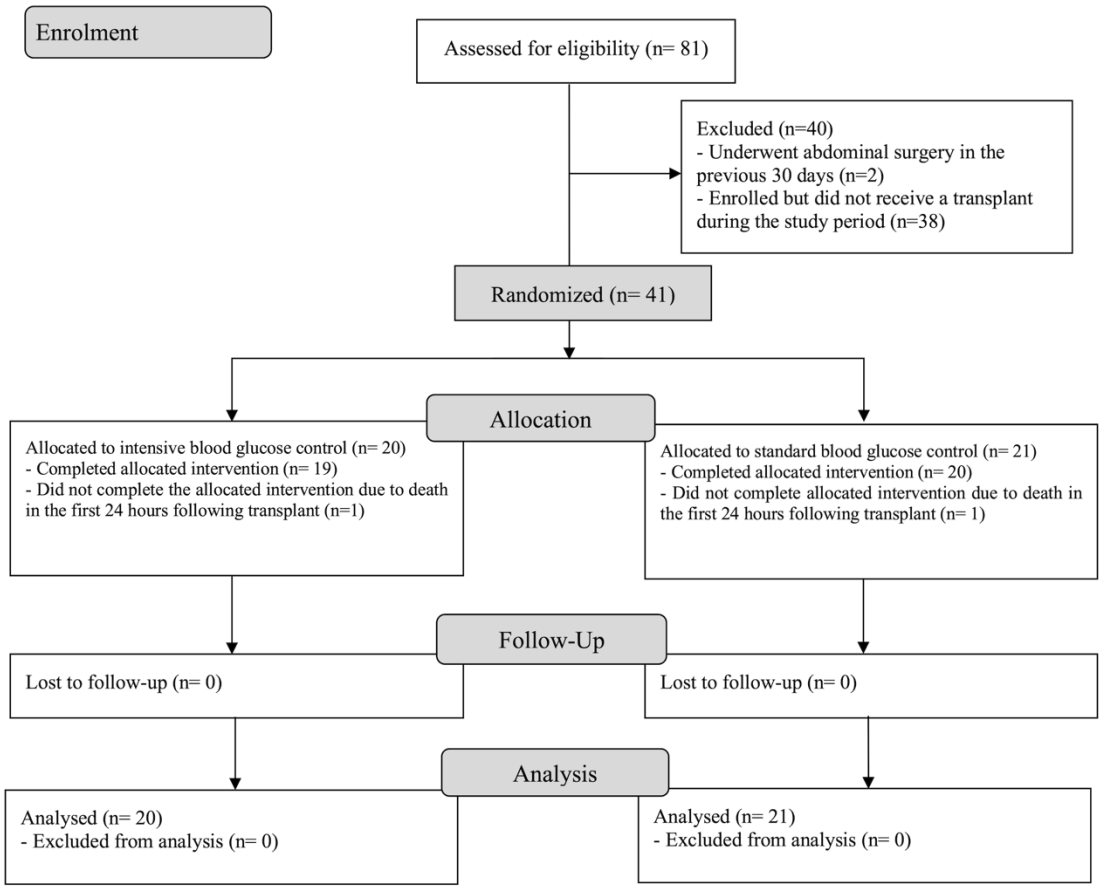

Figure 1. Trial enrolment and randomization flowchart