

Robotic Liver Transplantation in Recipients with Obesity

Jacopo Mascherini

University of Modena and Reggio Emilia

Cristiano Guidetti

University of Modena and Reggio Emilia

Roberta Odorizzi

University of Modena and Reggio Emilia

Barbara Catellani

University of Modena and Reggio Emilia

Giacomo Assirati

University of Modena and Reggio Emilia

Tiziana Olivieri

University of Modena and Reggio Emilia

Silvia Zamboni

University of Modena and Reggio Emilia

Paolo Magistri

University of Modena and Reggio Emilia

Gian Piero Guerrini

University of Modena and Reggio Emilia

Fabrizio Di Benedetto

fabrizio.dibenedetto@unimore.it

University of Modena and Reggio Emilia

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Abstract

Introduction:

Robotic liver transplantation (RLT) is an emerging minimally invasive approach, but experience in recipients with obesity remains limited. This study describes the operative strategy and short-term outcomes of deceased-donor whole-graft RLT in recipients with body mass index (BMI) ≥ 30 kg/m².

Methods

This retrospective single-center case series included consecutive recipients with obesity who underwent deceased-donor whole-graft RLT between January 2024 and April 2026. Perioperative and postoperative outcomes included conversion, ischemia times, intensive care unit (ICU) and hospital stay, postoperative complications, wound- and access-related morbidity, 90-day early allograft failure (EAF), mortality, and graft survival.

Results

Ten recipients underwent RLT. Median BMI was 31 kg/m² (IQR, 30–34.9), and 2 patients had Obesity $\geq$ III. Median MELD score was 10 (IQR, 7–15.8). Four grafts were procured from donation after circulatory death donors, and machine perfusion was used in 9 cases. Median operative time was 577.5 minutes (IQR, 570–656.25), estimated blood loss was 1150 mL (IQR, 500–2700), cold ischemia time was 320.5 minutes (IQR, 284.25–348.5), and warm ischemia time was 50 minutes (IQR, 44.75–58). No conversion to open surgery was required. Median ICU and hospital stay were 1 and 6 days, respectively. Within 90 days, 2 patients required readmission and reoperation. No 30- or 90-day mortality and no EAF occurred. At 5.3 months, all patients were alive with functioning grafts.

Conclusion

Deceased-donor whole-graft RLT was feasible without conversion and with acceptable short-term outcomes in recipients with obesity.

Key Points

- RLT was completed without conversion in 10 recipients with obesity.
- High-BMI recipients included patients with BMI > 40 and > 50 kg/m².
- No 90-day mortality or early allograft failure occurred.
- Tailored trocar placement and incision planning may support feasibility.

Introduction

Robotic liver transplantation (RLT) is an emerging surgical approach that aims to reduce the operative burden of liver transplantation (LT) through the application of minimally invasive technology. The concept was first introduced in the setting of living-donor LT, building on extensive prior experience in robotic living donor hepatectomy[1, 2]. Subsequently, the robotic approach was extended to deceased-donor whole-graft implantation, with early reports supporting its safety and feasibility[3, 4].

While robotic surgery has progressively expanded across the field of organ transplantation, especially in kidney transplantation, experience in LT recipients remains limited[5]. Furthermore, the available evidence mainly derives from highly selected cases treated at a few specialized centers, and data on technically demanding scenarios remain particularly scarce[6].

Obesity, defined as having a body mass index (BMI) ≥ 30 kg/m², has become a major global health burden, and its incidence has been steadily rising in the last decades[7]. It is also increasingly prevalent among patients referred for LT, particularly in the setting of the recently renamed metabolic dysfunction–associated steatotic liver disease (MASLD), whose global prevalence in the adult population is approximately 32%[8]. Accordingly, obesity per se is no longer considered an absolute contraindication to LT, although severe obesity and obesity-related comorbidities remain important factors in candidate selection[9, 10]. Nonetheless, obesity may add several layers of complexity to LT. From a technical standpoint, increased abdominal wall thickness and visceral adiposity can limit exposure, deepen the operative field, complicate hilar and vascular dissection, and increase the difficulty of vascular and biliary reconstruction. In addition, recipients with obesity often present with multiple associated medical problems that may contribute to postoperative morbidity, although current evidence remains conflicting as to whether obesity itself, rather than the associated cardiometabolic burden, independently affects post-transplant outcomes[11–13]. Although BMI alone does not fully capture the multidimensional risk profile of LT candidates, high-BMI recipients represent an increasingly common and clinically relevant population in which to assess the technical feasibility and potential role of RLT.

Herein, we report a case series of RLTs performed at our institution in recipients with obesity. The aim of this study is to describe the operative strategy, provide technical insights, and explore how the robotic approach may help address selected technical hurdles encountered in this population.

Patients and Methods

Study design

This is a retrospective, single-center case series of consecutive deceased-donor whole-graft RLTs performed at our institution between January 2024 and April 2026 in recipients with a BMI ≥ 30 kg/m².

The study aimed to describe perioperative and short-term postoperative outcomes in this selected population, including hospital and intensive care unit (ICU) length of stay, postoperative complications according to the Clavien-Dindo classification and the Comprehensive Complication Index (CCI), maximum in-hospital postoperative pain score on the Numerical Rating Scale (NRS), readmission rates, reoperation rates, 30-day and 90-day mortality, and graft survival. Given the focus on recipients with obesity, wound- and access-related complications were specifically recorded, including surgical site infection, wound dehiscence, seroma, incisional hernia, and port-site complications. The risk of early allograft failure (EAF) at 90 days was calculated using the Early Allograft Failure Simplified Estimation (EASE) score. Median follow-up was estimated using the reverse Kaplan-Meier method. Follow-up time was defined as the interval between transplantation and the last available clinical encounter or death.

Preoperative recipient variables included age, sex, BMI, transplant indication, American Society of Anesthesiologists (ASA) score, Charlson Comorbidity Index, previous abdominal surgery, and preoperative assessment of liver function using Model for End-Stage Liver Disease (MELD) score. Donor and graft characteristics included type of donation, age, sex, BMI, ICU length of stay, vasopressor use, graft weight, and Donor Risk Index (DRI).

Perioperative variables included operative time, estimated blood loss, conversion to open surgery, warm ischemia time, cold ischemia time, and duration of dual hypothermic oxygenated perfusion (D-HOPE). When D-HOPE was performed, perfusion time was subtracted from the overall ischemia time.

All patients provided written informed consent prior to LT. The study was approved by the local Institutional Review Board (approval number blinded for review) and conducted in accordance with the Declaration of Helsinki and the Declaration of Istanbul.

Operative technique

The operative technique for RLT has been previously described in detail[5]. Compared to the first published series, several modifications have since been implemented. Access to the peritoneal cavity is obtained through a surgical periumbilical or transumbilical incision, through which the AirSeal® trocar (Conmed Corp., FL, USA) is inserted. No additional assistant trocars are routinely used. In the standard approach, a 10–16 cm Pfannenstiel incision is used for native liver extraction and graft insertion.

In recipients with obesity, selected technical modifications were adopted to account for increased abdominal wall thickness and greater depth of the operative field. Compared with recipients with normal body habitus, the robotic trocar line was shifted cranially, and trocars were spaced more widely to optimize instrument triangulation and access to the upper abdomen. Furthermore, in selected patients, a lower midline incision was performed when abdominal size and increased peritoneal depth were judged to impair safe graft positioning through a suprapubic access. These technical adaptations are illustrated in Fig. 1.

Statistical analysis

Continuous variables were reported as medians with interquartile ranges (IQRs). Categorical variables were reported as frequencies and percentages. Data analysis was performed with StataNow/MP version 19.5 (StataCorp LLC, TX, USA).

Results

During the study period, 10 recipients with BMI ≥ 30 kg/m² underwent deceased-donor whole-graft RLT at our institution. Overall median BMI was 31 (IQR 30–34.9) kg/m², with 7 patients classified as Obesity I, 1 as Obesity II, 1 as Obesity III, and 1 as Obesity IV. Median age was 63 (48–66.8) years, and 8 patients were male. Median MELD score was 10 (7–15.8). MASLD was the most frequent underlying liver disease, present in 6 patients (60%). Hepatocellular carcinoma (HCC) was present at transplantation in 5 patients (50%). Median ASA score was 3 (2–3), and median Charlson Comorbidity Index was 6 (3–7). Recipients' baseline characteristics are presented in Table 1.

Table 1
baseline characteristics of recipients, donors, and grafts

	Overall	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6	Patient 7	Patient 8	Patient 9	Patient 10
Recipients											
Age (years)	63 (48–66.8)	59	67	62	66	68	61	48	64	73	50
Sex	M/F 80/20%	M	M	M	F	M	M	M	F	M	M
BMI (kg/m ²)	31 (30–34.9)	30	32	31.2	31.3	35.8	50.2	42.6	31.3	30.4	30.1
MELD score	10 (7–15.8)	8	10	8	15	7	16	29	29	7	10
HCC	5 (50%)	Yes	Yes	Yes	No	Yes	No	No	No	Yes	No
Underlying liver disease	MASLD (60%)	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No
	ALD (40%)	Yes	No	Yes	No	Yes	No	No	No	No	Yes
	Viral (30%)	Yes (HCV)	No	No	No	No	No	No	No	Yes (HCV)	Yes (HBV)
	Other (20%)	No	No	No	No	No	No	Yes (Wilson)	Yes (PBC)	No	No
ASA score	3 (2–3)	2	2	2	2	3	3	3	3	3	3
CCI	6 (3–7)	7	5	7	7	8	5	3	3	6	6
Previous surgery	3 (30%)	No	No	No	No	No	No	No	Yes	Yes	Yes
Donors and graft											
Donation	DBD/DCD 60/40%	DBD	DBD	DBD	DBD	DCD	DCD	DCD	DBD	DBD	DCD
Age (years)	72 (43–77.5)	72	72	43	79	85	76	66	68	69	78
Sex	M/F 50/50%	F	M	F	M	F	F	M	M	F	M
BMI (kg/m ²)	24.7 (23.9–28)	20	24	23	23.9	27	24	29	25	28	35
ICU length of stay (days)	4 (2.5–7)	4	2	2	2	9	8	13	4	4	4
Vasopressors	5 (50%)	No	Yes	Yes	Yes	No	No	Yes	Yes	No	No
Graft weight (g)	1225 (1125–1592.5)	1070	1600	1250	1100	1200	1000	1800	1200	1570	1200
DRI	2.204 (2.067–2.751)	2.119	2.050	1.498	2.119	3.196	2.694	2.770	1.861	2.289	3.093
Continuous variables presented as medians and interquartile ranges, categorical variables presented as frequencies and percentages.											
M: male, F: female, BMI: body mass index, MELD: model for end-stage liver disease, HCC: hepatocellular carcinoma, MASLD: metabolic dysfunction-associated liver disease, ALD: alcohol-related liver disease, HCV: hepatitis C virus, HBV: hepatitis B virus, PBC: primary biliary cholangitis, ASA: American Society of Anesthesiologists, CCI: Charlson Comorbidity Index, DBD: donation after brain death, DCD: donation after cardiac death, ICU: intensive care unit, DRI: Donor Risk Index.											

Donor and graft characteristics

Donor and graft characteristics are summarized in Table 1. Grafts were procured from donation after brain death (DBD) donors in 6 cases and from donation after circulatory death (DCD) donors in 4 cases. Median donor age was 72 (43–77.5) years, and median donor BMI was 24.7 (23.9–28) kg/m². Median DRI was 2.204 (2.067–2.751). D-HOPE was used in 9 grafts, with a median perfusion time of 133 (73–220) minutes. Median graft weight was 1225 (1125–1592.5) g.

Operative details

Median operative time was 577.5 (570–656.25) minutes, median estimated blood loss was 1150 (500–2700) mL. Intraoperative packed red blood cells (pRBC) transfusion was required in 5 patients (50%); the median number of pRBC units transfused in the overall cohort was 1 (0–3.5). Median cold ischemia time was 320.5 (284.25–348.5) minutes, and median warm ischemia time was 50 (44.75–58) minutes. No conversions to open surgery were required. A

lower midline incision was used in 5 patients when increased abdominal dimensions and depth of the peritoneal cavity were expected to impair safe graft positioning through suprapubic access. Median length of incision was 12.5 (11.25–13.75) cm. Operative details are reported in Table 2.

Table 2
intraoperative data

Operative time (min)	Overall	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6	Patient 7	Patient 8	Patient 9	Patient 10
	577.5 (570–656.25)	600	675	570	585	570	720	570	690	480	570
D-HOPE	9 (90%)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
D-HOPE duration (min)	133 (73–220)	162	90	116	73	97	220	287	-	528	133
Cold ischemia time (min)	320.5 (284.25–348.5)	373	311	214	351	278	330	247	341	572	303
Warm ischemia time (min)	50 (44.75–58)	72	59	48	39	55	63	44	42	47	52
Graft positioning (min)	4.5 (3–5)	10	5	5	7	3	5	4	3	2	3
Incision type		Midline	Midline	Midline	Suprapubic	Midline	Suprapubic	Midline	Suprapubic	Suprapubic	Suprapubic
Incision length (cm)	12.5 (11.25–13.75)	10	11	10	12	13	14	12	16	15	13
EBL (mL)	1150 (500–2700)	500	3400	800	1800	500	4000	500	3000	400	1500
Intraoperative pRBC (units)	1 (0–3.5)	0	0	0	2	0	15	4	15	0	2
Continuous variables presented as medians and interquartile ranges, categorical variables presented as frequencies and percentages.											
D-HOPE: dual hypothermic oxygenated perfusion, EBL: estimated blood loss, pRBC: packed red blood cells.											

Early postoperative outcomes

Median ICU stay was 1 (1–1.75) day, and median hospital length of stay was 6 (5–8.75) days. Within 30 days, postoperative complications occurred in 2 patients, with a maximum Clavien-Dindo grade of II. Median 30-day CCI was 0 (0–6.53). The median maximum in-hospital NRS pain score, assessed daily until discharge, was 4 (2–5). Within 90 days, 2 patients needed readmission and reoperation. Patient 4 developed persistent ascites attributed to caval anastomotic stenosis and underwent surgical rescue cavo-cavostomy. Patient 6 was admitted for wound dehiscence and incisional hernia, requiring surgical repair. Overall, cumulative median 90-day CCI was 0 (0–21.2). No 30- or 90-day mortality was observed.

Two patients had a predicted EAF risk greater than 10%. However, at a median follow-up of 5.3 (3.3–9.6) months, all patients were alive with functioning grafts. Postoperative outcomes are detailed in Table 3.

Table 3
postoperative outcomes

ICU stay (days)	Overall	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6	Patient 7	Patient 8	Patient 9	Patient 10
	1 (1–1.75)	1	1	1	5	1	3	1	2	1	1
LOS (days)	6 (5–8.75)	5	6	4	14	4	14	8	9	5	6
In-hospital NRS	4 (2–5)	3	2	4	6	5	5	8	2	3	3
Wound infection	0%	No	No	No	No	No	No	No	No	No	No
Wound dehiscence	10%	No	No	No	No	No	Yes	No	No	No	No
90-d re-admission	20%	No	No	No	Yes	No	Yes	No	No	No	No
Cause of re-operation	-	-	-	-	IVC anastomosis stenosis	-	Incisional hernia	-	-	-	-
30-d Clavien-Dindo highest grade		1	0	0	0	0	2	0	0	0	1
30-d CCI	0 (0–6.53)	8.7	0	0	0	0	20.9	0	0	0	8.7
90-d Clavien-Dindo highest grade		1	0	0	3b	0	3b	0	-	-	-
90-d CCI	0 (0–21.2)	8.7	0	0	33.7	0	39.7	0	-	-	-
EASE Score	-4.2 (-4.7 – -3.9)	- 4.3	- 4.8	- 5.3	- 3.9	- 4.2	- 2.0	- 3.9	- 1.5	- 5.1	- 4.2
90-d Risk of EAF	1.5 (1–2)	1%	1%	1%	2%	2%	12%	2%	18%	1%	1%
Follow-up (months)	5.3 (3.3–9.6)	26.4	18	16.7	9.6	5.7	4.9	4.9	2.8	2.7	2.0
Patient status at follow-up	Alive 100%	Alive	Alive	Alive	Alive	Alive	Alive	Alive	Alive	Alive	Alive
90-d EAF	0%	No	No	No	No	No	No	No	No	No	No
Continuous variables presented as medians and interquartile ranges, categorical variables presented as frequencies and percentages.											
ICU: intensive care unit, LOS: length of stay, 30-d: 30-day, 90-d: 90-day, CCI: comprehensive complication index, NRS: Numerical Rating Scale, IVC: inferior vena cava, EASE: Early Allograft Failure Simplified Estimation, EAF: early allograft failure.											

Discussion

This single-center case series reports the early experience with deceased-donor whole-graft RLT in recipients with obesity. The main findings of this study are that RLT was completed robotically in all patients without conversion to open surgery, no intraoperative complications were recorded, and no 30- or 90-day mortality occurred. In addition, all patients were alive with functioning grafts at last follow-up. These findings suggest that, in carefully selected recipients and within a highly experienced robotic transplant program, high BMI alone may not represent an absolute technical barrier to RLT.

Obesity represents an increasingly relevant issue in contemporary LT. The growing burden of MASLD has expanded the proportion of transplant candidates with increased BMI and associated cardiometabolic comorbidities. However, the impact of obesity on post-transplant outcomes remains complex. Several studies have reported increased short- and long-term morbidity in recipients with obesity[12–14], whereas others have questioned whether BMI independently predicts worse outcomes once associated medical problems, frailty, sarcopenia, disease severity, and center-level factors are considered[15–18]. Therefore, BMI should be interpreted as a pragmatic marker of body habitus rather than a comprehensive measure of operative risk. In this context, the present study should not be interpreted as evidence that BMI alone can guide selection for RLT, but rather as an early assessment of technical feasibility in a population that may pose specific access- and exposure-related challenges during minimally invasive LT.

From a technical standpoint, recipients with obesity may challenge the robotic approach in several ways. Increased abdominal wall thickness and visceral adiposity can reduce the effective working space, deepen the operative field, and make hilar dissection, vascular control, graft positioning, and vascular or biliary reconstruction more demanding. In the present series, specific technical adaptations were adopted to address these issues. Robotic trocars were shifted cranially and spaced more widely to improve triangulation and access to the upper abdomen. In addition, although suprapubic access is our standard

approach for native liver extraction and graft insertion, a lower midline incision was selectively used in this cohort when abdominal dimensions and increased peritoneal depth were expected to impair safe graft positioning through suprapubic access. This tailored strategy may be particularly relevant in recipients with obesity, in whom the challenge is not limited to the hepatectomy or implantation phases, but also includes safe graft introduction, orientation, and positioning before anastomosis.

The absence of conversion in this series is notable, particularly given the technical complexity of deceased-donor whole-graft implantation and the increased body habitus of the recipients. However, conversion is only one dimension of feasibility and does not fully capture operative complexity. In the present cohort, blood loss and transfusion requirements remained substantial, and median operative time was longer compared with previously published RLT experience, reflecting the demanding nature of RLT in this setting[5]. Ischemia times were comparable, although wider incisions were required[5]. Therefore, the present findings support feasibility rather than technical simplicity. They also reinforce the importance of careful patient selection, standardized operative planning, and progressive experience before extending RLT to recipients with more complex body habitus.

Overall postoperative outcomes were optimal in this selected cohort, with short median ICU and hospital length of stay and no early mortality. Importantly, no 90-day early allograft failure was observed, and all patients were alive with functioning grafts at last follow-up. Compared with previously published RLT experience, in which no major postoperative complications were reported, 2 patients in the present cohort required readmission and reoperation within 90 days[5]. One patient developed persistent ascites attributed to caval anastomotic stenosis and underwent surgical rescue cavocavostomy, whereas another developed wound dehiscence with incisional hernia requiring surgical repair. These events highlight that, despite the minimally invasive nature of RLT, recipients with obesity remain vulnerable to both graft-related and access-site complications. In particular, wound- and access-related morbidity should be specifically monitored in future studies, as one of the theoretical advantages of minimally invasive transplantation in recipients with obesity is the reduction of abdominal wall trauma. The occurrence of wound dehiscence and incisional hernia in one patient underscores that this potential advantage is not guaranteed and may depend on incision type, body habitus, tissue quality, immunosuppression, and postoperative course.

A key strength of this study is its focus on a clinically relevant but underreported subgroup within the emerging field of RLT. Early experiences with RLT have necessarily involved highly selected patients, and data on technically demanding scenarios remain limited. By specifically describing recipients with BMI ≥ 30 kg/m², this series provides practical information on operative planning, access strategy, graft positioning, and short-term outcomes in a population that is increasingly encountered in transplant practice. Moreover, the inclusion of deceased-donor whole-graft transplantation is relevant, as this setting differs substantially from living-donor partial graft implantation in terms of graft size, extraction and insertion logistics, ischemia management, and reconstruction strategy.

This study has several limitations. First, the sample size is small and the study is retrospective, single-center, and single-arm, precluding any comparison with open LT or with non-obese RLT recipients. Therefore, no conclusions can be drawn regarding superiority, equivalence, or reduction of wound-related morbidity compared with conventional open LT. Second, all procedures were performed within an experienced robotic and transplant program; therefore, the findings may not be generalizable to centers at earlier phases of the learning curve. Third, BMI was used as the defining criterion for obesity, although BMI alone does not capture the full spectrum of operative risk in LT candidates and could be altered by ascites and sarcopenia. Moreover, visceral fat distribution, cardiometabolic comorbidities, and donor/graft factors may all influence perioperative and graft-related outcomes. Finally, follow-up remains limited, especially for late complications such as incisional hernia, biliary strictures, and long-term graft outcomes.

In conclusion, this early experience suggests that deceased-donor whole-graft RLT can be performed in selected recipients with obesity without conversion and with acceptable short-term patient and graft outcomes. High BMI alone should not be considered an absolute technical contraindication to RLT, but careful selection, tailored access strategy, and extensive expertise in both robotic hepatobiliary surgery and LT remain essential. Larger comparative studies with longer follow-up are needed to define optimal selection criteria, assess reproducibility, and determine whether minimally invasive access offers measurable benefits over open transplantation in recipients with obesity.

Declarations

Author Contribution

J.M.: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Writing – Original Draft, Writing – Review & Editing. C.G.: Conceptualization, Methodology, Investigation, Writing – Original Draft, Writing – Review & Editing. R.O.: Investigation, Data Curation, Visualization, Writing – Review & Editing. B.C.: Investigation, Data Curation, Visualization, Writing – Review & Editing. G.A.: Investigation, Data Curation, Writing – Review & Editing. T.O.: Investigation, Data Curation, Writing – Review & Editing. S.Z.: Investigation, Data Curation, Writing – Review & Editing. P.M.: Conceptualization, Methodology, Supervision, Writing – Review & Editing. G.P.G.: Conceptualization, Supervision, Writing – Review & Editing. F.D.B.: Conceptualization, Project Administration, Supervision, Writing – Review & Editing.

Data Availability

The data used and analyzed during the current study are available from the corresponding author upon request and subject to Institutional Review Board approval.

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Figures

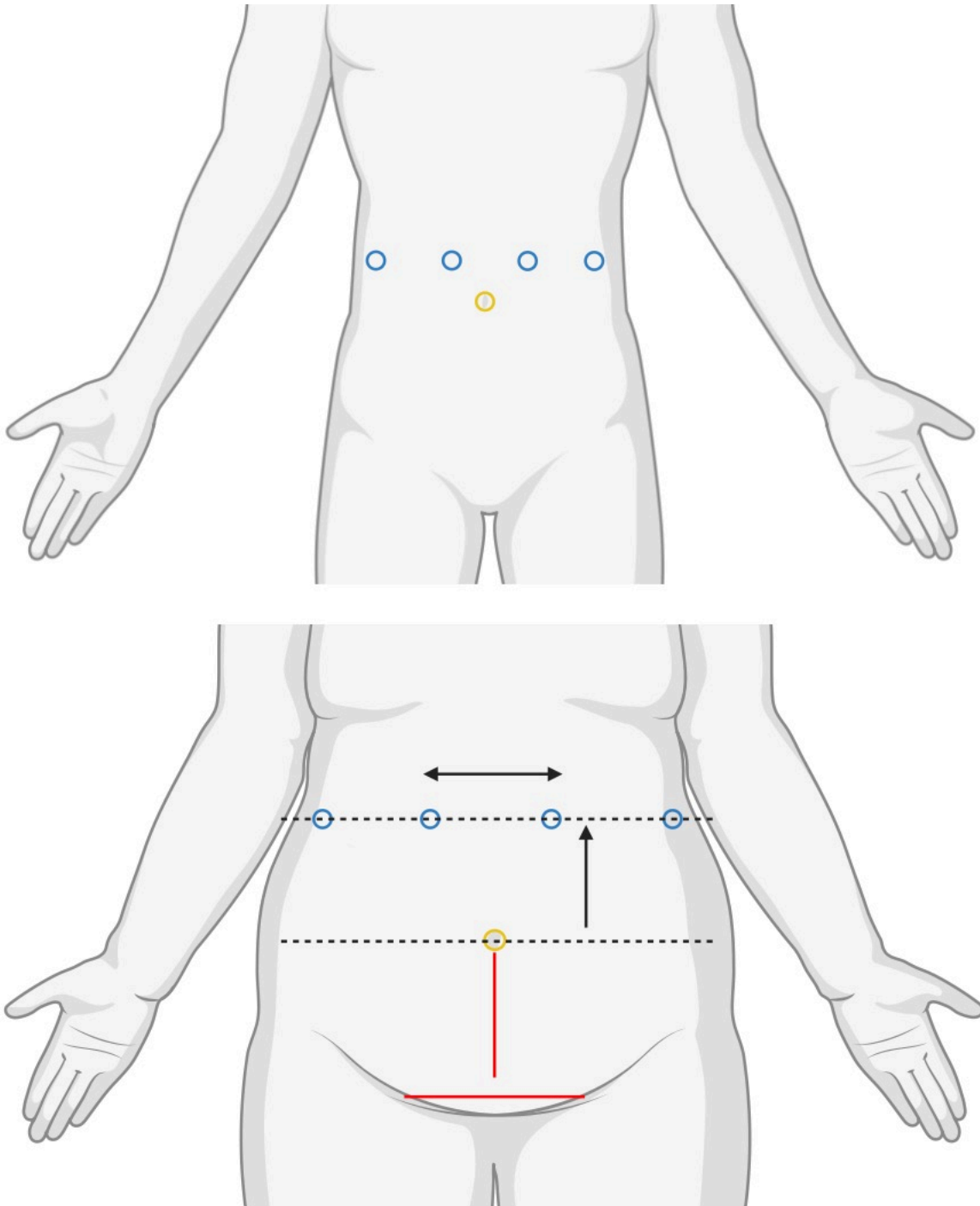


Figure 1

Technical modifications in trocar positioning and incision planning for recipients with obesity undergoing robotic liver transplantation. The robotic trocar line (dashed line), parallel to the transverse umbilical line (dashed line), is shifted cranially, and the trocars are placed widely apart to optimize access to the upper abdomen and instrument triangulation (blue circles). In patients with normal body habitus, a suprapubic incision is routinely used for native liver extraction and graft insertion; however, in selected recipients with obesity, a lower midline incision was performed when difficult graft positioning through suprapubic access was anticipated (red lines). The AirSeal® trocar is inserted through a periumbilical open access (yellow circle), and no additional assistant trocar is routinely used.