livers

Review

Minimally Invasive Surgery in Liver Transplantation: From Living Liver Donation to Graft Implantation

Eleni Avramidou *, Konstantinos Terlemes, Afroditi Lymperopoulou, Georgios Katsanos, Nikolaos Antoniadis, Athanasios Kofinas, Stella Vasileiadou, Konstantina-Eleni Karakasi and Georgios Tsoulfas

Department of Transplant Surgery, Center for Research and Innovation in Solid Organ Transplantation Aristotle University of Thessaloniki School of Medicine, 54642 Thessaloniki, Greece; terlemesk@gmail.com (K.T.); alymperop@auth.gr (A.L.); katsanosg@auth.gr (G.K.); nikanton@auth.gr (N.A.); kofinasthanasis@gmail.com (A.K.); stvasileiadou@gmail.com (S.V.); ke_karakasi@hotmail.com (K.-E.K.); tsoulfasg@auth.gr (G.T.)

* Correspondence: avramidoue@auth.gr

Abstract: Since the end of the 20th century and the establishment of minimally invasive techniques, they have become the preferred operative method by many surgeons. These techniques were applied to liver surgery for the first time in 1991, while as far as transplantation is concerned their application was limited to the living donor procedure. We performed a review of the literature by searching in Pubmed and Scopus using the following keywords: Liver transplantation, Minimally invasive surgery(MIS) living liver donor surgery. Applications of MIS are recorded in surgeries involving the donor and the recipient. Regarding the recipient surgeries, the reports are limited to 25 patients, including combinations of laparoscopic, robotic and open techniques, while in the living donor surgery, the reports are much more numerous and with larger series of patients. Shorter hospitalization times and less blood loss are recorded, especially in centers with experience in a large number of cases. Regarding the living donor surgery, MIS follows the same principles as a conventional hepatectomy and is already the method of choice in many specialized centers. Regarding the recipient surgery, significant questions arise mainly concerning the safe handling of the liver graft.

Keywords: MIS; liver transplantation; donor surgery; recipient surgery; living donor liver transplantation; robotic hepatectomy; liver transplantation

Citation: Avramidou, E.; Terlemes, K.; Lymperopoulou, A.; Katsanos, G.; Antoniadis, N.; Kofinas, A.; Vasileiadou, S.; Karakasi, K.-E.; Tsoulfas, G. Minimally Invasive Surgery in Liver Transplantation: From Living Liver Donation to Graft Implantation. *Livers* **2024**, *4*, 119–137. https://doi.org/10.3390/livers4010009

Academic Editor: Burcin Ekser

Received: 26 December 2023
Revised: 23 January 2024
Accepted: 5 February 2024
Published: 17 February 2024

1. Introduction

Since the beginning of minimally invasive and laparoscopic surgeries in the late 20th century, many surgeons use this method as their preferred approach regarding hepatectomy [1].The term of minimally invasive surgery (MIS) refers to the usage of smaller incisions for access, as an alternative to the regular open technique [2]. MIS techniques offer multiple advantages including less postoperative pain and better cosmetic results [3]. MIS is applicable to the majority of surgical procedures, including complex operations and some core ones, like cholecystectomy and appendectomy [4].

Today, MIS has evolved from the field of experimental medicine to daily clinical practice. Contraindications that used to exist were complexity of the surgery and existence of incisions in the abdominal area. Nowadays, the efficacy and safety of MIS, even on patients with the above contraindications, has been scientifically proven [5]. The above findings have led to the application of MIS in liver transplant recipients as well as living liver donors, with potentially better outcomes than the traditional open techniques [6,7].

MIS is a surgical approach option in liver surgeries since 1991, with the first laparoscopic resection reported by H. Reich [8]. Since that time and with the recent technological developments, MIS liver surgeries has increased [9]. The most common MIS liver surgeries include local non-anatomical resection and left lateral segmentectomy, with procedures like isolated caudate lobectomy, trisegmentectomy and middle hepatic lobectomy (segments 4, 5, and 8) being more rare but still a feasible option [10–12].

According to the above, MIS can be an applicable approach in many surgeries related to liver transplantation (LT). MIS techniques in liver transplantation were first used in 2002 in living donor liver donation, when Cherqui et al. first reported resection of left lobe liver graft with laparoscopy [13]. In the past, application of MIS techniques has been a matter of debate due to the fear of graft loss. During recent years, MIS application reports in LT recipients have increased, with the majority of them relating to the treatment of postoperative applications [7].

To the best of our knowledge, there is no review summarizing the current status of minimal invasive approach in LT patients and donors. Thus, the present narrative review was conducted to assess the minimally invasive approach in this cohort of patients with focus on living donor surgery and liver transplant recipient surgery.

2. Materials and Methods

We conducted a literature review of the medical research databases PubMed and Scopus. We used the following key words for our search: Liver transplantation, Minimally Invasive surgery, living donor hepatectomy and recipient surgery. Our research was limited to the period from 2000 to the present and includes studies written in the English language. Our exclusion criteria included articles in languages other than English, studies that were not human-related, and bibliographies that did nor refer to application of MIS techniques in LT.

3. Results

Applications of MIS in living donor surgeries can be found in Tables 1 and 2, while applications of MIS regarding recipient surgery can be found in Table 3.

3.1. Minimally Invasive Surgical Techniques in Living Donor LT

3.1.1. Laparoscopic Donor Hepatectomy

Cherqui et al. in 2002 were the first to perform laparoscopic left hepatic lobectomy in two donors for living donor liver transplantation. Operations lasted 6–7 h, with minimal blood loss and no complications [13]. Regarding adult living donor LT, pure laparoscopic donor left hepatectomy was first reported eleven years later, in 2013 [14]. The successful surgeries demonstrated the potential for laparoscopic donor left lobectomy as a safe and effective method for pediatric and adult living donor liver transplantation, signaling a significant advancement. In recent years, laparoscopic major hepatectomy has been standard practice among expert teams. In a laparoscopy-assisted donor right hepatectomy (LADRH), the donor is placed in the supine position with arms abducted. If the hand assisted technique is chosen, a midline subxiphoid incision measuring 8 cm is created to provide hand assistance during the mobilization of the liver and the extraction of the graft. After using a 5-mm umbilical camera port to view the liver, an additional 5-mm port is inserted either at the right flank or through the Gel Port. The surgeon, positioned on the right side of the donor, employs hook-type electrocautery through the right flank port to dissect and divide the ligaments, continuing the mobilization process until reaching the lateral aspect of the inferior vena cava [15]. Regarding the Left hepatectomy (LALDH), the donor position and settings of the laparoscopic procedure were the same as the right hemihepatectomy [16,17]. In the Pure Laparoscopic Left Lateral Sectionectomy (PLLLDS), five trocars are inserted: three of 12-mm diameter and two of 5-mm diameter and a 30-degree laparoscope is employed for visual assessment of the liver. The mobilization of the left lateral section is accomplished by cutting the round, falciform, and left triangular ligaments using a harmonic scalpel [18]. Regarding operative time in LALDH, it ranged from 265 min to 702.50, with different operation times being reported between left lateral and left hemihepatectomy, as well as differences occurring in different centers based on the surgical experience of each [14,19–32]. Additionally, Takahara et al. and Seong et al.found that operative time in LALDH was shorter than the pure laparoscopic left donor hepatectomy (PLLDH) [26,30]. As for the right hepatectomy, operative time ranged from 181.0 min to 1065 min. [26,31,33–50], with the differences being reported caused mainly by the surgical experience of each center.

Post Operative Outcome in Laparoscopy Assisted Donor Hepatectomy

Hospital stay of donors ranged from 4 days to 50 days, with shorter hospital stay being reported in LLS [31,39,42]. Min et al. and Song et al. reported a slightly shorter hospital stay for LADH group than the PLDH group [21,30]. Concerning blood loss, this parameter ranged from 10 mL to 1559 mL, with the minimal blood loss being reported by Scarton et al. in LLLS and maximum blood loss being reported in a case of hybrid laparoscopic donor hepatectomy [18,27].

Complications were evaluated using the Clavien-Dindo Classification (I–IV). Major complications (grade III and above) were reported by Song et al. and included post-operative ileus, hemorrhage which required laparotomy and post hepatectomy liver failure [30]. Kitajima et al. also reported three bile leakage cases requiring endoscopic nasobiliary drainage in left liver hepatectomy living donors [27]. Safwan et al. reported two major complications that included one patient that developed postoperative bleeding which required re-laparotomy and one patient that required video-assisted thoracoscopic surgery for the management of loculated pleural effusion [23]. Choi et al. in their series of patients reported pleural effusion, biliary stricture and diaphragmatic hernia [29]. Makki et al. also reported eight cases of donors with major complications requiring intervention [28]. T. Kobayashi et al. reported only one major complication occurring in LLLS [27]. Lastly, Marubashi et al. reported two patients with delayed gastric emptying which required fiberoptic endoscopy for correcting rotation of the stomach, and both recovered within two weeks after the donor surgery [28]. Regarding the postoperative pain, this is reported to be less than in the conventional open technique [51].

3.1.2. Robotic Assisted (RA) Donor Hepatectomy

In recent years many experienced centers and surgeons published their series of surgeries including all types of hepatectomy. The first ever right lobe robotic living donor hepatectomy was performed in 2011 by Guilianotti at the University of Chicago-Illinois, who already had years of experience in robotic MIS [52]. Chen et al. were the first to publish a series of robotic right lobe donor hepatectomy in 13 donors and compared them with 54 open living donor hepatectomy cases [53]. When it comes to robotic Left lateral sectionectomy, Liao et al. were the first to attempt it [54]. Four years later, Troisi et al. were the first to perform a series of 25 robotic left lateral sectionectomies and compare them with 50 laparoscopic left lateral sectionectomies, completing the series of patients with zero conversions with the robotic approach compared to two with the laparoscopic [55]. In the last couple of years Robotic living donor hepatectomy (RLDH) is starting to gain attention internationally with a few other experienced centers publishing their results as you can see in Table 2 [56,57]. In 2020 a combination of Right lobectomy (RL), Left Lateral Sectionectomy (LLS), and Left lobectomy (LL) surgeries were performed by Broering et al. and 2 years later Schulze et al. published their series of 501 RLDH including RL, LL and LLS with very encouraging results, showing that experience with robotic surgery makes it possible to perform any kind of robotic living donor hepatectomy regardless of anatomical variations and graft size [58,59]. The operation time in those series of surgeries ranged between 290–596 min. Naranjo et al. found that RLDH lasted on average 133.4 min longer than OLDH and 137.7 min longer than LLDH [60].

Post Operative Outcome in RA LDH

The intraoperative blood loss ranged from 50–1000 mL, but in general it was very similar to OLDH (open living donor hepatectomy) and slightly less than LADH (laparoscopy assisted donor hepatectomy) [58,61]. All studies comparing the length of postoperative hospital stay between ODH and RLDH found it to be lower in RLDH. Rho et al.were the only ones not to find any differences in hospital stay between LADH and RLDH [61] In a systematic review/meta-analysis comparing RLDRH and ODRH, Naranjo et al. found no differences in postoperative mean peak ALT and AST levels respectively, but the postoperative mean peak total bilirubin level was lower in RLDRH. When they compared the Robotic living donor right hepatectomy (RLDRH) versus the Laparoscopic assisted donor right hepatectomy (LADRH) they showed that the postoperative mean peak ALT and AST levels were higher in RLDRH. Conversely, it was shown that there was no difference in the postoperative mean peak total bilirubin level. [60]. In the same systematic review, when comparing the postoperative pain of RLDH vs. OLDH (>day 3) they found no differences, but when comparing RLDH to LLDH, the pain score after day 3 was lower in RLDH. [60]. Complications were evaluated using the Clavien-Dindo Classification (I–IV) [62–64]. Most common complications included pleural effusion, biliary leak and hepatic artery bleeding and thrombosis.

3.2. Minimally Invasive Surgical Techniques in LT Recipient

Even though MIS techniques are widely used in Hepato-pancreato-biliary (HPB) surgery the last several years, their application in liver transplant recipient surgery is minimized to 25 reported patients, with 8 of them requiring conversion to open surgery [15,65–68]. Eguchi et al. were the first to describe the possible applications of MIS in LT recipient surgery [69]. Particularly they applied a hand-assisted laparoscopic surgery approach in 9 LT recipients though the explant of the diseased liver and then they converted the surgery to open through an upper midline incision. Even though they mentioned higher warm ischemia times compared to the conventional open technique, their technique showed no further limitations and proposed advantages mainly concerning the smaller incision that was applied. The following ten years no reported attempt was made concerning the introduction of MIS in LT recipients. Dokmak et al. were the first that attempted pure laparoscopic total hepatectomy in LT recipients, applying a hybrid LT surgery [65]. The following year, in 2021, Suh et al. were the first to successfully proceed to a pure laparoscopic LT both for the hepatectomy and for the graft implantation in the recipient [65,66]. Moreover, Lee et al. were the first to introduce the robotic assisted system in recipient LT surgery, by applying a hybrid laparoscopic and robotic LT approach [66]. Lastly, experimental MIS LT surgeries have been carried out successfully using experimental animals [70].

3.2.1. Explant Surgery

In all seven reports regarding MIS in LT recipient surgery the hepatectomy part of the liver transplantation was done laparoscopically. This surgical procedure follows the same principles as any partial hepatectomy, with some modifications in vessel clamping and division of vascular structures [71–73]. Mean surgical time ranged from 390–1220 min and warm ischemia time range was 30–117 min. In the beginning of the operation five trocars of various diameters are placed. In cases of a recipient with unresectable liver cancer, the surgeon observed the cavity for possible metastasis of the tumor [65]. Then, the procedure continues with cholecystectomy and lymphadenectomy in case of recipients with liver tumors. The hilar dissection includes the dissection of both branches of the hepatic artery, of the common bile duct, as well as the dissection of the portal vein based on the principles of pringle manoeuvre, a common approach in partial liver resection surgeries [74]. Additionally, the hepatectomy included the preparation of the recipient's right hepatic vein for the anastomosis with the grafts vessels [67]. It should also be mentioned that Dokman et al., were the first reported surgeons to succeed with the MIS LT approach. They facilitated the total hepatectomy by removing the liver with a two step procedure, by first applying a left lateral sectionectomy and then removing the rest of the liver [65].

3.2.2. Graft Implantation Surgery

After the total hepatectomy, the next step in the LT is the graft implantation. The MIS approach for graft implantation includes open surgery though an upper midline incision, laparoscopic surgery or even robotic assisted surgery purely or in combination with other techniques [65–69,75]. In the laparoscopic and robotic assisted surgeries, a gel port was frequently placed in the incision of the previous liver extraction, that could be used as a hand port in case of an emergency [66–70]. Additionally, a small incision was made in the left upper quadrant for the insertion of the Chitwood clamp for the suprahepatic IVC clamping as well as the implantation of the liver graft [66,67]. After the reperfusion, in some approaches the surgery switched from laparoscopic to robotic assisted [66]. The last step included the laparoscopic or robotic assisted en- to-end anastomosis of the bile duct [76].

3.2.3. Post Operative Outcome in LT Using MIS Technique

Median range of hospital stay was 11–28 days and blood loss ranged from 250–3600 mL. LT is a major procedure with many major or minor complications [76–83]. Some of the most common post-operative LT complications that require surgical intervention include biliary complications (biliary peritonitis, biliary leakage, biliary stricture), internal hernias, ascites, abscesses and rejection-related complications [84–88]. Interventional radiology procedures can be used for the management of some of these complications with great success [87]. In cases that require surgical intervention, there is the potential for a MIS approach in the treatment of post LT complications [87–92].

Table 1. Applications of Laparoscopic assisted surgery in living donor hepatectomy surgery.

Authors	Date of Publication	Type of Study	N of Patients	Type of Surgery	Operative Time (min)	Blood Loss (mL)	Conversion Rate	Complications	Total Hospital Stay (Days)
Moon et al. [36]	2022	Retrospective study	3	Right hepatectomy	565–750	200–300	0/3	Bile leakage (1)	9–15
SuhKyun et al. [15]	2022	Comparative study	213	Righ hepatectomy	289.9 ± 54.9	306.1 ± 213.1	NA	Wound problem (3), Pulmonary thromboembolism (1), biliary problem (20), Intra-abdominal fluid collection (1), portal vein thrombus (1), Pleural effusion (1), bleeding (1)	20.6 ± 15.4
Hong et al. [31]	2021	Retrospective multicenter Study	545	Right Hepatectomy (481) Left Hepatectomy (25) LLS (39)	Right hepatectomy: 340.1 ± 106. Left hepatectomy 308.5–409 LLS 341.6 ± 66.2	302.5 Right hepatectomy 316.3 ± 233.7 Left hepatectomy 300.0 (150.0–400.0) LLS139.5 ± 117.2	10/545	Wound problem (7), pleural effusion (13), intra-abdominal fluid collection (4), bile leakage (15), portal vein thrombosis (2), pulmonary thromboembolism (1), biliary stricture (3), portal vein stenosis (1), intra abdominal bleeding (4), shock (1)	9.4 Right hepatectomy: 9.4 ± 3.6 Left hepatectomy: 7.0–10.0 LLS: 9.2 ± 2.8
Han et al. [38]	2021	Comparative study	100 (43 before the learning curve, 57 after the learning curve	Right hepatectomy	Before: 282.2 ± 59.2 After: 181.0 ± 35.7	Before: 344.4 ± 224.0 After: 161.4 ± 130.0	NA	Before:Intra-abdominal fluid collection (2) Biliary stricture (1), intra abdominal bleeding (1) After: Portal vein thrombosis (1)	Before: 7.1 ± 2.4 After: 5.8 ± 1.4
Han et al. [44]	2021	retrospective case series.	300 donors divided into three subgroups of periods 1–3 of 100 cases each: 1–100, 101–200, and 201–300	Right hepatectomy	267.8 ± 74.2	261.5 ± 209.8	NA	Wound problem (3), pleural effusion (1), intra-abdominal fluid collection (6), portal vein thrombosis (1), pulmonary thromboembolism (1), portal vein stenosis (2), bilary problems (4), bleeding (1)	7.4 ± 2.6
Cho et al. [45]	2021	Comparative study	90	Right hepatectomy	364	175	0/90	None	8.2
Seon Jeong et al. [34]	2020	Report	123	Right hepatectomy (119) Extenede right hepatectomy (4)	335 ± 95	300		Pleural effusion (29), Atelectasia (9), Bile leakage (7), bile duct stricture (3), bleeding (1), portal vein narrowing (1), fluid collection (2), wound complications (7)	9 (8–11)

Table 1. *Cont.*

Authors	Date of Publication	Type of Study	N of Patients	Type of Surgery	Operative Time (min)	Blood Loss (mL)	Conversion Rate	Complications	Total Hospital Stay (Days)
Lee et al. [39]	2019	Scientific report	35	Right hepatectomy	433.7± 142.9	572.2 ± 438.9	2/35	Wound problems (3), portal vein thrombosis (1), portal vein stricture (1), bleeding (1)	9.70 ± 4.35
Rhu et al. [47]	2019	Comparative study	100	Right hepatectomy	375.2 ± 94.0	299.3 ± 161.7	6/100	Wound problem (1), ileus (3), fluic collection (1), biliary complication (8), bleeding (1).	11.0 ± 4.0
Park J et al. [40]	2019	Case-control study	91	Right hepatectomy	345	300	NA	Wound problems (3), bile leakage (11), fluid collection (1), biliary complications (1), vascular complications (2)	10
Song et al. [32]	2019	Case report	1	left hepatectomy.	495	<100	NA	None	6
Kwon et al. [33]	2018	Retrospective cohort study	54	Right without MHV (41) Extended right with MHV (10) Left with MHV (3)	436 (294–684)	300 (10–850)	4/54	Wound infection (3), ileus (2), bile leakage (10) portal vein stenosis (3), bleeding (1)	10 (7–27)
Broering et al. [51]	2018	Observational study	72	LLS		100 (50–600) mL	3/72	Bile leakage (2)	4.1 ± 1.33
Lee et al. [49]	2018	Retrospective study	115	Right hepatectomy	321.5 ± 57.2 min	394.1 ± 197.6	NA	Wound problems (2), pleural effusion (1), intra-abdominal fluid collection (2), portal vein thrombosis (1), bile leakage (1), biliary stricture (1), bleeding (1)	7.8 ± 1.8
Hong et al. [37]	2018	Retrospective study	26	Right hepatectomy	304.5 (58.7)		0/26	Intra-abdominal fluid collection (1), bleeding (1), hepatic xiphoid trocar injury (2)	7.7 ± 3.0
Song et al. [30]	2018	Comparative study	7 PLRH 26 HARH	Right hepatectomy	PLRH: 509.3 ± 98.9. HARH: 451.6 ± 89.7	PLRH: 378.6 ± 177.1 HARH: 617.3 ± 240.4		PLRH: Pleural effusion (1), infection (1) HARH: Bile leakage (2), ileus (1), infection (1), hemorrhage (1), Liver failure (1)	PLRH: 7.7–10 HARH: 7.5–12 (8.5)
Safwan et al. [23]	2018	Retrospective Comparative study	19	Hybrid Right hepatectomy	375.5 ± 51.9	228.9 ± 123.1	NA	Ileus (2), deep vein thrombosis (1), Thrombophlebitis (1), fluid collection (1), bile leakage (1)	NA

Table 1. *Cont.*

Authors	Date of Publication	Type of Study	N of Patients	Type of Surgery	Operative Time (min)	Blood Loss (mL)	Conversion Rate	Complications	Total Hospital Stay (Days)
Suh et al. [43]	2018	Comparative study	45	Right hepatectomy	330.7 ± 49.5 min	436.0 ± 170.3	NA	Intra abdominal bleeding (5), intra abdominal fluid collection (4), wound problems (5), hepatic artery problems (4), portal vein or hepatic vein problems (2), biliary problems (12) other complications (9)	PLRDH: 8.2 ± 1.3 days
Kobayashi et al. [20]	2018	Retrospective study	11	Graft type (right lobe/left lobe/posterior section/left lateral section) LAP ASSISTED 4/5/1/1	475 (400–645)	350 (15–1128)	NA	biliary fistula (1)	10 (7–19) days
Eguchi et al. [69]	2018	Comparative study	110	right hemihepatectomy: 43, extended left Hemihepatectomy: 66, and right lateral sectionectomy: 1	405 (286–671)	537	NA	Wound problem (1), bile leak (3), ileus (2), bleeding (2), portal vein thrombosis (1)	13 (6–40)
Rotellar et al. [41]	2017	Comparative study	5	Right hepatectomy	476 (420–480)	<200	0/5	Infection (2)	4 (3–5)
Kim et al. [56]	2017	Case reports	3	LDRH	447–502	200–270	0/3	NA	7–8
Kitajima et al. [27]	2017	Observational study	76	Right hepatectomy: 41 Left hepatectomy: 35	Right: 431 (310–651) Left: 459 (310–633)	Right: 201 (10–1559) Left: 245 (22–1840), no transfusions	5/76	NA	Right: 12 (8–27) Left: 12 (7–50)
Takahara et al. [26]	2017	Comparative study	40:LADH 14: PLDH	Left and right hepatectomies	LADH: 380.40 ± 44.08. PLDH: 454.93 ± 85.60	PLDH 81.07 ± 52.78 LADH 238.50 ± 177.05		PLDH: biliary complications (3) LADH: biliary complications (4).wound infections (2) other complication (1)	LADH 9.05 ± 3.30 PLDH 8.43 ± 1.65
Scatton. et al. [18]	2015	Prospective cohort study	70	67 donors underwent LLS, and 3 underwent LH without middle hepatic vein procurement.	175–520	10–770	4/70	biliary leakage (2), Biliary stenosis (1) Pulmonary complications (2) Pneumothorax (1), Respiratory infection (1) Bladder injury (1) Wound complications (5) Infection (1) Hematoma (4) Gastric ulcer (1)	hospital stay 3–18

Table 1. *Cont.*

Authors	Date of Publication	Type of Study	N of Patients	Type of Surgery	Operative Time (min)	Blood Loss (mL)	Conversion Rate	Complications	Total Hospital Stay (Days)
Suh et al. [24]	2015	Comparative study	14	Right hepatectomy	333.8 ± 61.7	298.3 ± 118.8	NA	None	8.4 ± 1.6
Han et al. [48]	2015	Case report	2	Right Hepatectomy	NA	NA	NA	None	10 8
Makki et al. [28]	2014	Observational study	26	Right hepatectomy	336.54 ± 89.40	702.50 ± 124.11	NA	Wound problems (3), pleural effusion (1)	NA
Zhang et al. [22]	2014	Prospective case matched study	25	Right hepatectomy	385.9 ± 47.4	378.4 ± 112.5	NA	Pleural effusion (1), pulmonary infection (2), bleeding (1),	7.0 ± 1.4
Soubrane et al. [42]	2013	Case report	1	Right hepatectomy	480	100	NA	none	7
Samstein et al. [14]	2013	Case report	2	left Hepatectomy	358 and 379	125	0/2	Bile leakage (1)	5-3
Marubashi et al. [19]	2013	Retrospective comparative study	31	Left hepatectomy	435 ± 103	353 ± 39.6	NA	NA	10.3 ± 3.3
Choi et al. [29]	2012	Retrospective comparative study	40:SPLADRH 20: LADRH	Right hepatectomy	Single port 278.50 ± 72.25 Laparoscopy assisted 383.55 ± 41.73	Singles port 450.0 ± 316.43 Laparoscopy assisted 870.0 ± 653.01	SPLADRH: 2/40 LADRH: 2/20	SPLADRH: pleural effusion (1), bile leakage (3), bleeding (2) LADRH: wound complication (2), pleural effusion (2), billary stricture (1)	Single port 11.8 ± 4.45 Laparoscopy assisted 12.1 ± 2.81
Baker et al. [25]	2009	Comparative study	33	Right hepatectomy	265 ± 48	417 ± 217	2/33	NA	4.3
Soubrane et al. [93]	2006	Retrospective comparative study	16	Left lateral sectionectomy	320 ± 67 min	18.7 ± 44.2 mL	None	wound hematomas (2) 1bile leak (1)	7.5 ± 2.3 days
Koffron et al. [94]	2006	Case report	1	Right hepatectomy	235	150	NA	NA	3
Seog et al. [21]	2006	Comparative study	20	LADH: LLS 7 Left: 1 Right: Y 1 PLDH: LLS 4 Left 6	Lap-assisted 351.0 ± 137.7 Pure Lap 458 ± 123.0	NA	1/10 Lap assisted	Lap-Assist group: atelectasis (2) bile leakage (1)	Lap Assisted 16.4 Pure lap 11.5
Cherqui et al. [13]	2002	Case series	2	Left hepatic lobectomy	360 420	150 and 450	NA	None-	7 5

NA: Not applicable, MHV: Main hepatic vein, LLS: Left lateral sectionectomy, HARH: Hand assisted right hepatectomy, LH: Left hepatectomy, RH: Right hepatectomy, PLDH: Pure laparoscopic donor hepatectomy, LADH: Laparoscopy assisted donor hepatectomy, SLADRH: Single port laparoscopy assisted donor right hepatectomy, LADRH: Laparoscopy assisted donor right hepatectomy.

Table 2. Applications of Robotic Surgery in living donor surgery.

Authors	Date of Publication	Type of Study	N of Patients	Type of Hepatectomy	Operative Time (min)	Average Blood Loss (mL)	Convention Rate	Complications	Length of Hospital Stay (Days)
Kim et al. [56]	2022	Retrospective cohort study	102	RL	464	104	NA	NA	8.7 ± 3.1
Schulze et al. [59]	2022	Cohort study	501	RL, LL, LLS	406.2	60 (20–800)	2/501	Abdominal fluid collection (3),beeding (2), bile leakage (9), deep vein thrombosis (2), hematoma (12), pulmonary embolism (3)	4 (2–22)
Jeong Jang et al. [57]	2022	Case series	10	RL	396.6 ± 62.7	NA	0/10	None	8.7 ± 2.6
Rho et al. 2022 [61]	2022	Comparative study	52	RL	493.6 ± 91.5	109.8 ± 101.5	NA	Minor complications (10), pleural effusion (1) hepatic artery bleeding (1)	9 ± 2.1
Troisi et al. [55]	2021	Retrospective comparative study	25	LLS	290 ± 45	50 (30–250)	0/25	None	3 (2–5)
Broering et al. [58]	2020	Single Center review	175	80 RL, 34 LL, 61 LLS	424 (177–693)	138.1 (20–1000)	NA	biliary leak (3)	4.3 (2–22)
Broering et al. [51]	2020	Comparative study using propensity score matching.	35	RL	504 ± 73.5	250 (100–800)	NA	Minor complications (2), biliary leak (1), pulmonary embolism (1)	5 (3–12)
Liao et al. [54]	2017	Case Report	1	LLS	390	400	NA	None	8
Chen et al. [53]	2016	Case Series	13	RL	596 (353–753)	169 (50–500)	NA	Hepatic artery thrombosis (1), biliary complications (1)	7.0 (6–8)
Guilianotti et al. [52]	2011	Case Report	1	RL	460	350	NA	Late portal vein stenosis	5

NA: Non applicable, RL: Right lobectomy, LL: Left lobectomy, LLS: Left lateral sectionectomy.

Table 3. Applications of MIS in liver transplant recipients.

Authors	Date of Publication	Type of Study	N of Patients	Type of Surgery	Conversion Rate	Anhepatic Phase (min)	Ischemia (min)	Operative Time (min)	Blood Loss (mL)	Complications	Total Hospital Stay (Days)
Kim et al. [67]	2023	Case series	10	Laparoscopic (explant) Open (implant)	6/10	48–152	Cold: 105–234 Warm: 23–117	400–840	600–24.200	Bleeding	14
Dokmak et al. [68]	2022	Case series	6	Laparoscopic (explant) Open (implant)	NA	40–67 min	cold: 360–575 warm: 30–40	390–450	250–600	NA	10–14
Suh et al. [48]	2022	Case report	1	Laparoscopic (explant) Laparoscopic-robotic (implant)	No	NA	NA	1065	500	Bleeding at the site of the suprapubic incision	13
Lee et al. [66]	2022	Case report	1	Laparoscopic (explant) Robotic (implant)	No	NA	Warm: 87 Cold: 220	1220	3600	Mild reperfusion syndrome, Renal dysfunction, mild periportal edema, early graft dysfunction and postoperative ascites	19
Suh et al. [15]	2021	Case series	5	Laparoscopic (explant) Open (implant)	2/5	25–201 min	Warm: 27–56 min	499–640 min	1750–7800 ml	bile leakage (2) and bleeding (1)	15–30
Dokmak et al. [65]	2020	Case report	1	Laparoscopic (explant) Open (implant)	No	43 min	Warm: 38 min Cold: 466 min	400 min	400 mL	Mild ischemia reperfusion syndrome	15

NA: Not applicable.

4. Discussion

To the best of our knowledge, this is the first review in the literature addressing the minimally invasive approach in the context of LT, both in donors and in recipients. Compared to the applications of MIS in other fields of surgery, there has been a delay in the incorporation of minimally invasive approaches in LT particularly in recipients, mainly fearing the possible damage or loss of the grafts. All of the MIS applications in LT recipient surgeries are dated after 2020 and include total MIS, combination of MIS and open techniques and laparoscopic and robotic surgical approaches.

The main concern and reason of the small number of LT recipients being operated with MIS is the maintenance of safety of the patient and the graft. The most common complications that lead to the conversion of the surgery include massive haemorrhage and hemodynamic instability of the patient. For this reason, a practical solution could be the utilization of hand assisted technique for the facilitation of emergency interventions by the surgeon, as well as the application of a Chitwood clamp and multiple laparoscopic bulldog clamps [46]. Moreover, based on the docking that the robotic surgery requires, a safer more time efficient approach for the implantation part of the surgery would be the one of laparoscopic surgery [46]. Additionally, MIS application in recipient surgeries seems to be more suitable for smaller liver grafts [15].

Apart from the main safety concerns regarding MIS applications in LT, another main point of consideration is the long and difficult learning curve of MIS applications in these complex surgeries. It is reported that the learning curve for laparoscopic surgeries is steep, in contrast with the simpler linear curve of the open techniques [94,95]. Moreover, according to recent European guidelines, training in laparoscopic liver surgeries should follow a stepwise progression from open to laparoscopic and then robotic surgical techniques, which due to the limited number and specialized nature of these procedures, training in MIS should be part of fellowship programs [96,97]. Another point of consideration is that up to today, very few liver transplant centers apply MIS techniques in everyday clinical practice, limiting training possibilities. These obstacles can be overcome with the usage of various simulation and VR applications. It has been reported that the application of technology in surgical education has positive outcomes leading to less complications and shorter operative time, even in complex surgeries [98–104].

Another reason for the limited application of MIS techniques in everyday clinical practice in liver transplantation is the financial cost. Generally, surgeries applying MIS techniques cost more than the open surgery alternative, with cost increases sometimes reaching even 100% [105–108]. The additional cost includes the equipment needed for those surgeries as well as the training of the surgeon and stuff (nurses, technicians etc.). Particularly, the cost of the equipment is the main reason that explains the cost differences between different MIS techniques and specifically between laparoscopic and robotic surgeries, with robotic assisted surgery equipment costing more [105].

Regardless of the surgical technique applied, in LT and LLD surgeries postoperative complications such as hernias and bile duct injuries can occur. MIS techniques have been applied in treating those complications, even in LT recipients that have a previous abdomen surgery. Most of the surgical interventions treat early postoperative complications, occurring in the first months after LT, particularly from day 5 till 8 months post operation [90–92]. Usage of robotic assisted surgery has been reported for the successful management of late anastomotic biliary stricture even 2 years after transplantation [88]. Incisional hernias are a very common post operative complication in open LT [109–120]. Unlike others, MIS approach for incisional hernia repair has been well documented regardless of when it occurred [111–120].

Despite the many difficulties MIS applications in LT surgeries may pose, there are several advantages for both the donor and the recipient. Concerning the recipient LT surgery, among the main advantages of the minimally invasive approach is the control of tissue damage as a trigger of the innate systemic inflammatory response, i.e., fewer acute phase reactants, lower CRP and complement, synthesis and activation of macrophages, and natural killer and endothelial cells [121]. Moreover, there is a reduction in hospital stay and thus a lower risk of infectious complications [122]. The above advantages in combination with the decreased possibility of wound infection due to smaller incisions can prove to be very beneficial in transplant recipients who receive immunosuppression [123]. MIS have significant advantages for the donor surgery as well, mainly including better cosmetic outcome, shorter hospital stay and less perioperative pain, all of these being factors which apart from the well-being of the donor, are also bound to increase donation rates [124,125].

MIS applications in LT surgeries are still very limited with no official evidence-based guidelines yet. Rho et al. are the only ones reporting some indications regarding applications of robotic assisted surgery techniques in living donor liver surgery [61]. With the known superiority of minimally invasive techniques in obese patients, it is right to suggest the evidence based application of those techniques in LLD surgeries of obese donors, increasing this way the number of possible living donor liver donations [126]. Generally, it is reported that centers with experience and a higher volume of robotic surgeries managed to achieve shorter operative times. On the other hand, centers with less exposure to such procedures had an extended length of surgical time.. Based on the existing literature, the decision of application of MIS in LT and LLD should be made based on the patient characteristics and wishes as well as the experience of the transplant centre and surgeon.

Because of the limited applications of MIS techniques in LT, it is difficult to define its limitations as well as its advantages. Our review also has some limitations. Some of them include the quality and the degree of evidence of the studies, as it is limited mostly to single-center case series studies. Prospective cohort and randomized control trial studies should be held in the future in order to systematically record the advantages and limitation of applications of these type of surgeries in LT.

5. Conclusions

This review summarizes the reports of MIS in the LT surgeries, from the liver living donor surgery to the treatment of long term postoperative complications. For the optimal systematic evaluation of the effect of these type of surgeries in LT, national and international registries of LT surgeries, for the better investigation of preoperative and long-term outcomes should be organized.

Author Contributions: E.A. conceptualized the idea; visualized, collected, and analyzed the data; and wrote the manuscript. K.T. provided resources, analyzed the data and wrote the manuscript; A.L. provided resources, analyzed the data and wrote the manuscript; G.K. critically reviewed the manuscript; N.A. critically reviewed the manuscript; A.K. critically reviewed the manuscript; K.-E.K. critically reviewed the manuscript; S.V. critically reviewed the manuscript and G.T. supervised, assisted with the data curation, and edited the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Bhattacharya, K. Kurt Semm: A laparoscopic crusader. *J. Minimal Access Surg.* **2007**, *3*, 35–36. [CrossRef]
2. Jaffray, B. Minimally invasive surgery. *Arch. Dis. Child.* **2005**, *90*, 537–542. [CrossRef]
3. Majeed, A.W.; Troy, G.; Smythe, A.; Reed, M.W.R.; Stoddard, C.J.; Peacock, J.; Johnson, A.G.; Nicholl, J. Randomised, prospective, single-blind comparison of laparoscopic versus small-incision cholecystectomy. *Lancet* **1996**, *347*, 989–994. [CrossRef]
4. Tsui, C.; Klein, R.; Garabrant, M. Minimally invasive surgery: National trends in adoption and future directions for hospital strategy. *Surg. Endosc.* **2013**, *27*, 2253–2257. [CrossRef]
5. Feldbrügge, L.; Wabitsch, S.; Benzing, C.; Krenzien, F.; Kästner, A.; Haber, P.K.; Atanasov, G.; Andreou, A.; Öllinger, R.; Pratschke, J.; et al. Safety and feasibility of laparoscopic liver resection in patients with a history of abdominal surgeries. *HPB* **2019**, *22*, 1191–1196. [CrossRef] [PubMed]
6. Lopez-Lopez, V.; Ruiz, A.G.; Pelegrin, P.; Abellán, B.; Lopez-Conesa, A.; Brusadin, R.; Cayuela, V.; García, A.; Campos, R.R. Impact of Immune Response in Short-term and Long-term Outcomes After Minimally Invasive Surgery for Colorectal Liver Metastases: Results from a Randomized Study. *Surg. Laparosc. Endosc. Percutaneous Tech.* **2021**, *31*, 690–696. [CrossRef] [PubMed]

7. López-López, V.; Martínez-Serrano, M.Á.; Ruiz-Manzanera, J.J.; Eshmuminov, D.; Ramirez, P. Minimally invasive surgery and liver transplantation: Is it a safe, feasible, and effective approach? *Updates Surg.* **2023**, *75*, 807–816. [CrossRef] [PubMed]
8. Reich, H.; McGlynn, F.; DeCaprio, J.; Budin, R. Laparoscopic excision of benign liver lesions. *Obstet. Gynecol.* **1991**, *78 Pt 2*, 956–958. [PubMed]
9. Cai, X. Laparoscopic liver resection: The current status and the future. *Hepatobiliary Surg. Nutr.* **2018**, *7*, 98–104. [CrossRef] [PubMed]
10. Schmelzle, M.; Krenzien, F.; Schöning, W.; Pratschke, J. Laparoscopic liver resection: Indications, limitations, and economic aspects. *Langenbeck's Arch. Surg.* **2020**, *405*, 725–735. [CrossRef] [PubMed]
11. Morise, Z. Laparoscopic liver resection for posterosuperior tumors using caudal approach and postural changes: A new technical approach. *World J. Gastroenterol.* **2016**, *22*, 10267–10274. [CrossRef] [PubMed]
12. Nguyen, K.T.; Laurent, A.; Dagher, I.; Geller, D.A.; Steel, J.; Thomas, M.T.; Marvin, M.; Ravindra, K.V.; Mejia, A.; Lainas, P.; et al. Minimally invasive liver resection for metastatic colorectal cancer: A multi-institutional, international report of safety, feasibility, and early outcomes. *Ann. Surg.* **2009**, *250*, 842–848. [CrossRef]
13. Cherqui, D.; Soubrane, O.; Husson, E.; Barshasz, E.; Vignaux, O.; Ghimouz, M.; Branchereau, S.; Chardot, C.; Gauthier, F.; Fagniez, P.-L.; et al. Laparoscopic living donor hepatectomy for liver transplantation in children. *Lancet* **2002**, *359*, 392–396. [CrossRef]
14. Samstein, B.; Cherqui, D.; Rotellar, F.; Griesemer, A.; Halazun, K.J.; Kato, T.; Guarrera, J.; Emond, J.C. Totally laparoscopic full left hepatectomy for living donor liver transplantation in adolescents and adults. *Am. J. Transplant. Off. J. Am. Soc. Transplant. Am. Soc. Transpl. Surg.* **2013**, *13*, 2462–2466. [CrossRef]
15. Suh, K.-S.; Hong, S.-K.; Hong, K.; Han, E.S.; Hong, S.Y.; Suh, S.; Lee, J.-M.; Choi, Y.; Yi, N.-J.; Lee, K.-W. Minimally Invasive Living Donor Liver Transplantation: Pure Laparoscopic Explant Hepatectomy and Graft Implantation Using Upper Midline Incision. *Liver Transplant. Off. Publ. Am. Assoc. Study Liver Dis. Int. Liver Transplant. Soc.* **2021**, *27*, 1493–1497. [CrossRef]
16. Soyama, A.; Takatsuki, M.; Adachi, T.; Kitasato, A.; Torashima, Y.; Natsuda, K.; Tanaka, T.; Yamaguchi, I.; Tanaka, S.; Kinoshita, A.; et al. A hybrid method of laparoscopic-assisted open liver resection through a short upper midline laparotomy can be applied for all types of hepatectomies. *Surg. Endosc.* **2014**, *28*, 203–211. [CrossRef]
17. Soyama, A.; Takatsuki, M.; Hidaka, M.; Muraoka, I.; Tanaka, T.; Yamaguchi, I.; Kinoshita, A.; Hara, T.; Eguchi, S. Standardized less invasive living donor hemihepatectomy using the hybrid method through a short upper midline incision. *Transplant. Proc.* **2012**, *44*, 353–355. [CrossRef]
18. Scatton, O.; Katsanos, G.; Boillot, O.; Goumard, C.; Bernard, D.; Stenard, F.; Perdigao, F.; Soubrane, O. Pure laparoscopic left lateral sectionectomy in living donors: From innovation to development in France. *Ann. Surg.* **2015**, *261*, 506–512. [CrossRef]
19. Marubashi, S.; Wada, H.; Kawamoto, K.; Kobayashi, S.; Eguchi, H.; Doki, Y.; Mori, M.; Nagano, H. Laparoscopy-assisted hybrid left-side donor hepatectomy. *World J. Surg.* **2013**, *37*, 2202–2210. [CrossRef]
20. Kobayashi, T.; Miura, K.; Ishikawa, H.; Soma, D.; Ando, T.; Yuza, K.; Hirose, Y.; Katada, T.; Takizawa, K.; Nagahashi, M.; et al. Long-term Follow-up of Laparoscope-Assisted Living Donor Hepatectomy. *Transplant. Proc.* **2018**, *50*, 2597–2600. [CrossRef]
21. Min, S.K.; Han, H.S.; Kim, S.W.; Park, Y.H.; Lee, H.O.; Lee, J.H. Initial experiences with laparoscopy-assisted and total laparoscopy for anatomical liver resection: A preliminary study. *J. Korean Med. Sci.* **2006**, *21*, 69. [CrossRef] [PubMed]
22. Zhang, X.; Yang, J.; Yan, L.; Li, B.; Wen, T.; Xu, M.; Wang, W.; Zhao, J.; Wei, Y. Comparison of Laparoscopy-Assisted and Open Donor Right Hepatectomy: A Prospective Case-Matched Study from China. *J. Gastrointest. Surg.* **2014**, *18*, 744–750. [CrossRef] [PubMed]
23. Safwan, M.; Nagai, S.; Collins, K.; Rizzari, M.; Yoshida, A.; Abouljoud, M. Impact of abdominal shape on living liver donor outcomes in mini-incision right hepatic lobectomy: Comparison among 3 techniques. *Liver Transplant. Off. Publ. Am. Assoc. Study Liver Dis. Int. Liver Transplant. Soc.* **2018**, *24*, 516–527. [CrossRef] [PubMed]
24. Suh, S.W.; Lee, K.W.; Lee, J.M.; Choi, Y.R.; Yi, N.J.; Suh, K.S. Clinical outcomes of and patient satisfaction with different incision methods for donor hepatectomy in living donor liver transplantation. *Liver Transplant.* **2014**, *21*, 72–78. [CrossRef] [PubMed]
25. Baker, T.B.; Jay, C.L.; Ladner, D.P.; Preczewski, L.B.; Clark, L.; Holl, J.; Abecassis, M.M. Laparoscopy-assisted and open living donor right hepatectomy: A comparative study of outcomes. *Surgery* **2009**, *146*, 817–823, discussion 823–825. [CrossRef] [PubMed]
26. Takahara, T.; Wakabayashi, G.; Nitta, H.; Hasegawa, Y.; Katagiri, H.; Umemura, A.; Takeda, D.; Makabe, K.; Otsuka, K.; Koeda, K.; et al. The First Comparative Study of the Perioperative Outcomes Between Pure Laparoscopic Donor Hepatectomy and Laparoscopy-Assisted Donor Hepatectomy in a Single Institution. *Transplantation* **2017**, *101*, 1628–1636. [CrossRef] [PubMed]
27. Kitajima, T.; Kaido, T.; Iida, T.; Seo, S.; Taura, K.; Fujimoto, Y.; Ogawa, K.; Hatano, E.; Okajima, H.; Uemoto, S. Short-term outcomes of laparoscopy-assisted hybrid living donor hepatectomy: A comparison with the conventional open procedure. *Surg. Endosc.* **2017**, *31*, 5101–5110. [CrossRef] [PubMed]
28. Makki, K.; Chorasiya, V.K.; Sood, G.; Srivastava, P.K.; Dargan, P.; Vij, V. Laparoscopy-assisted hepatectomy versus conventional (open) hepatectomy for living donors: When you know better, you do better. *Liver Transplant.* **2014**, *20*, 1229–1236. [CrossRef]
29. Choi, H.J.; You, Y.K.; Na, G.H.; Hong, T.H.; Shetty, G.S.; Kim, D.G. Single-port laparoscopy-assisted donor right hepatectomy in living donor liver transplantation: Sensible approach or unnecessary hindrance? *Transplant. Proc.* **2012**, *44*, 347–352. [CrossRef]
30. Song, J.L.; Yang, J.; Wu, H.; Yan, L.N.; Wen, T.F.; Wei, Y.G.; Yang, J.Y. Pure laparoscopic right hepatectomy of living donor is feasible and safe: A preliminary comparative study in China. *Surg. Endosc.* **2018**, *32*, 4614–4623. [CrossRef]

31. Hong, S.K.; Choi, G.S.; Han, J.; Cho, H.D.; Kim, J.M.; Han, Y.S.; Cho, J.Y.; Kwon, C.H.D.; Kim, K.H.; Lee, K.W.; et al. Pure Laparoscopic Donor Hepatectomy: A Multicenter Experience. *Liver Transplant. Off. Publ. Am. Assoc. Study Liver Dis. Int. Liver Transplant. Soc.* **2021**, *27*, 67–76. [CrossRef] [PubMed]
32. Song, J.L.; Wu, H.; Yang, J.Y. Pure three-dimensional laparoscopic full left hepatectomy of a living donor for an adolescent in China. *Chin. Med. J.* **2019**, *132*, 242–244. [CrossRef] [PubMed]
33. Kwon, C.H.D.; Kwon, C.H.D.; Choi, G.S.; Kim, J.M.; Cho, C.W.; Rhu, J.; Kim, G.S.; Sinn, D.H.; Joh, J.W. Laparoscopic Donor Hepatectomy for Adult Living Donor Liver Transplantation Recipients. *Liver Transplant. Off. Publ. Am. Assoc. Study Liver Dis. Int. Liver Transplant. Soc.* **2018**, *24*, 1545–1553. [CrossRef] [PubMed]
34. Jeong, J.S.; Wi, W.; Chung, Y.J.; Kim, J.M.; Choi, G.S.; Kwon, C.H.D.; Han, S.; Gwak, M.S.; Kim, G.S.; Ko, J.S. Comparison of perioperative outcomes between pure laparoscopic surgery and open right hepatectomy in living donor hepatectomy: Propensity score matching analysis. *Sci. Rep.* **2020**, *10*, 5314. [CrossRef] [PubMed]
35. Cho, H.D.; Samstein, B.; Chaundry, S.; Kim, K.H. Minimally invasive donor hepatectomy, Systemic Review. *Int. J. Surg.* **2020**, *82*, 187–191. [CrossRef]
36. Moon, H.H.; Jo, J.H.; Choi, Y.I.; Shin, D.H. Outcomes of Pure Laparoscopic Living Donor Right Hepatectomy at a Small-Volume Center. *Exp. Clin. Transplant. Off. J. Middle East Soc. Organ Transplant.* **2022**, *20*, 402–407. [CrossRef]
37. Hong, S.K.; Lee, K.W.; Choi, Y.; Kim, H.S.; Ahn, S.W.; Yoon, K.C.; Kim, H.; Yi, N.J.; Suh, K.S. Initial experience with purely laparoscopic living-donor right hepatectomy. *Br. J. Surg.* **2018**, *105*, 751–759. [CrossRef]
38. Han, E.S.; Lee, K.W.; Suh, K.S.; Yi, N.J.; Choi, Y.; Hong, S.K.; Lee, J.M.; Hong, K.P.; Hong, S.Y.; Suh, S. Shorter operation time and improved surgical outcomes in laparoscopic donor right hepatectomy compared with open donor right hepatectomy. *Surgery* **2021**, *170*, 1822–1829. [CrossRef]
39. Lee, B.; Choi, Y.; Han, H.S.; Yoon, Y.S.; Cho, J.Y.; Kim, S.; Kim, K.H.; Hyun, I.G. Comparison of pure laparoscopic and open living donor right hepatectomy after a learning curve. *Clin. Transplant.* **2019**, *33*, e13683. [CrossRef]
40. Park, J.; Kwon, D.C.H.; Choi, G.S.; Kim, S.J.; Lee, S.K.; Kim, J.M.; Lee, K.W.; Chung, Y.J.; Kim, K.S.; Lee, J.S.; et al. Safety and Risk Factors of Pure Laparoscopic Living Donor Right Hepatectomy: Comparison to Open Technique in Propensity Score-matched Analysis. *Transplantation* **2019**, *103*, e308–e316. [CrossRef]
41. Rotellar, F.; Pardo, F.; Benito, A.; Zozaya, G.; Martí-Cruchaga, P.; Hidalgo, F.; Lopez, L.; Iñarrairaegui, M.; Sangro, B.; Herrero, I. Totally Laparoscopic Right Hepatectomy for Living Donor Liver Transplantation: Analysis of a Preliminary Experience on 5 Consecutive Cases. *Transplantation* **2017**, *101*, 548–554. [CrossRef]
42. Soubrane, O.; Cotta, F.P.; Scatton, O. Pure laparoscopic right hepatectomy in a living donor. *Am. J. Transplant. Off. J. Am. Soc. Transplant. Am. Soc. Transpl. Surg.* **2013**, *13*, 2467–2471. [CrossRef] [PubMed]
43. Suh, K.S.; Hong, S.K.; Lee, K.W.; Yi, N.J.; Kim, H.S.; Ahn, S.W.; Yoon, K.C.; Choi, J.Y.; Oh, D.; Kim, H. Pure laparoscopic living donor hepatectomy: Focus on 55 donors undergoing right hepatectomy. *Am. J. Transplant. Off. J. Am. Soc. Transplant. Am. Soc. Transpl. Surg.* **2018**, *18*, 434–443. [CrossRef] [PubMed]
44. Han, E.S.; Suh, K.S.; Lee, K.W.; Yi, N.J.; Hong, S.K.; Lee, J.M.; Hong, K.P.; Tan, M.Y. Advances in the surgical outcomes of 300 cases of pure laparoscopic living donor right hemihepatectomy divided into three periods of 100 cases: A single-centre case series. *Ann. Transl. Med.* **2021**, *9*, 553. [CrossRef] [PubMed]
45. Cho, H.D.; Kim, K.H.; Yoon, Y.I.; Kang, W.H.; Jung, D.H.; Park, G.C.; Hwang, S.; Ahn, C.S.; Moon, D.B.; Ha, T.Y.; et al. Comparing purely laparoscopic versus open living donor right hepatectomy: Propensity score-matched analysis. *Br. J. Surg.* **2021**, *108*, e233–e234. [CrossRef] [PubMed]
46. Suh, K.S.; Hong, S.K.; Lee, S.; Hong, S.Y.; Suh, S.; Han, E.S.; Yang, S.M.; Choi, Y.; Yi, N.J.; Lee, K.W. Purely laparoscopic explant hepatectomy and hybrid laparoscopic/robotic graft implantation in living donor liver transplantation. *Br. J. Surg.* **2022**, *109*, 162–164. [CrossRef] [PubMed]
47. Rhu, J.; Choi, G.S.; Kim, J.M.; Joh, J.W.; Kwon, C.H.D. Feasibility of total laparoscopic living donor right hepatectomy compared with open surgery: Comprehensive review of 100 cases of the initial stage. *J. Hepato-Biliary-Pancreat. Sci.* **2020**, *27*, 16–25. [CrossRef] [PubMed]
48. Han, H.S.; Cho, J.Y.; Yoon, Y.S.; Hwang, D.W.; Kim, Y.K.; Shin, H.K.; Lee, W. Total laparoscopic living donor right hepatectomy. *Surg. Endosc.* **2015**, *29*, 184. [CrossRef]
49. Lee, K.W.; Hong, S.K.; Suh, K.S.; Kim, H.S.; Ahn, S.W.; Yoon, K.C.; Lee, J.M.; Cho, J.H.; Kim, H.; Yi, N.J. One Hundred Fifteen Cases of Pure Laparoscopic Living Donor Right Hepatectomy at a Single Center. *Transplantation* **2018**, *102*, 1878–1884. [CrossRef]
50. Suh, K.S.; Hong, S.K.; Lee, S.; Hong, S.Y.; Suh, S.; Han, E.S.; Yang, S.M.; Choi, Y.; Yi, N.J.; Lee, K.W. Pure laparoscopic living donor liver transplantation: Dreams come true. *Am. J. Transplant. Off. J. Am. Soc. Transplant. Am. Soc. Transpl. Surg.* **2022**, *22*, 260–265. [CrossRef]
51. Broering, D.C.; Elsheikh, Y.; Shagrani, M.; Abaalkhail, F.; Troisi, R.I. Pure Laparoscopic Living Donor Left Lateral Sectionectomy in Pediatric Transplantation: A Propensity Score Analysis on 220 Consecutive Patients. *Liver Transplant. Off. Publ. Am. Assoc. Study Liver Dis. Int. Liver Transplant. Soc.* **2018**, *24*, 1019–1030. [CrossRef]
52. Giulianotti, P.C.; Tzvetanov, I.; Jeon, H.; Bianco, F.; Spaggiari, M.; Oberholzer, J.; Benedetti, E. Robot-assisted right lobe donor hepatectomy. *Transpl. Int.* **2012**, *25*, e5–e9. [CrossRef] [PubMed]
53. Chen, P.-D.; Wu, C.-Y.; Hu, R.-H.; Ho, C.-M.; Lee, P.-H.; Lai, H.-S.; Lin, M.-T.; Wu, Y.-M. Robotic liver donor right hepatectomy: A pure, minimally invasive approach. *Liver Transplant.* **2016**, *22*, 1509–1518. [CrossRef] [PubMed]

54. Liao, M.-H.; Yang, J.-Y.; Wu, H.; Zeng, Y. Robot-assisted Living-donor Left Lateral Sectionectomy. *Chin. Med. J.* **2017**, *130*, 874–876. [CrossRef] [PubMed]
55. Troisi, R.I.; Elsheikh, Y.; Alnemary, Y.; Zidan, A.; Sturdevant, M.; Alabbad, S.; Algoufi, T.; Shagrani, M.; Broering, D.C. Safety and Feasibility Report of Robotic-assisted Left Lateral Sectionectomy for Pediatric Living Donor Liver Transplantation: A Comparative Analysis of Learning Curves and Mastery Achieved with the Laparoscopic Approach. *Transplantation* **2021**, *105*, 1044–1051. [CrossRef] [PubMed]
56. Kim, N.R.; Han, D.H.; Choi, G.H.; Lee, J.G.; Joo, D.J.; Kim, M.S.; Choi, J.S. Comparison of surgical outcomes and learning curve for robotic versus laparoscopic living donor hepatectomy: A retrospective cohort study. *Int. J. Surg.* **2022**, *108*, 107000. [CrossRef] [PubMed]
57. Jang, E.J.; Kim, K.W.; Kang, S.H. Early Experience of Pure Robotic Right Hepatectomy for Liver Donors in a Small-Volume Center. *JSLS J. Soc. Laparoendosc. Surg.* **2022**, *26*, e2022.00063. [CrossRef] [PubMed]
58. Broering, D.C.; Zidan, A. Advancements in Robotic Living Donor Hepatectomy, Review of Literature and Single-Center Experience. *Curr. Transpl. Rep.* **2020**, *7*, 324–331. [CrossRef]
59. Schulze, M.; Elsheikh, Y.; Boehnert, M.U.; Alnemary, Y.; Alabbad, S.; Broering, D.C. Robotic surgery and Liver Transplantation: A single-center experience of 501 robotic donor hepatectomies. *Hepatobiliary Pancreat. Dis. Int.* **2022**, *21*, 334–339. [CrossRef]
60. Lincango Naranjo, E.P.; Garces-Delgado, E.; Siepmann, T.; Mirow, L.; Solis-Pazmino, P.; Alexander-Leon, H.; Restrepo-Rodas, G.; Mancero-Montalvo, R.; Ponce, C.J.; Cadena-Semanate, R.; et al. Robotic Living Donor Right Hepatectomy: A Systematic Review and Meta-Analysis. *J. Clin. Med.* **2022**, *11*, 2603. [CrossRef]
61. Rho, S.Y.; Lee, J.G.; Joo, D.J.; Kim, M.S.; Kim, S.I.; Han, D.H.; Choi, J.S.; Choi, G.H. Outcomes of Robotic Living Donor Right Hepatectomy From 52 Consecutive Cases: Comparison With Open and Laparoscopy-assisted Donor Hepatectomy. *Ann. Surg.* **2022**, *275*, e433–e442. [CrossRef]
62. Dindo, D.; Demartines, N.; Clavien, P.-A. Classification of surgical complications: A new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann. Surg.* **2004**, *240*, 205–213. [CrossRef]
63. Chung, D.A.; Sharples, L.D.; Nashef, S.A.M. A case-control analysis of readmissions to the cardiac surgical intensive care unit. *Eur. J. Cardio-Thorac. Surg.* **2002**, *22*, 282–286. [CrossRef]
64. Clavien, P.-A.; Camargo, C.A., Jr.; Croxford, R.; Langer, B.; Levy, G.A.; Greig, P.D. Definition and Classification of Negative Outcomes in Solid Organ Transplantation Application in Liver Transplantation. *Ann. Surg.* **1994**, *220*, 109–120. [CrossRef]
65. Dokmak, S.; Cauchy, F.; Sepulveda, A.; Choinier, P.M.; Dondéro, F.; Aussilhou, B.; Hego, C.; Chopinet, S.; Infantes, P.; Weiss, E.; et al. Laparoscopic Liver Transplantation: Dream or Reality? The First Step with Laparoscopic Explant Hepatectomy. *Ann. Surg.* **2020**, *272*, 889–893. [CrossRef]
66. Lee, K.-W.; Choi, Y.; Hong, S.K.; Lee, S.; Hong, S.Y.; Suh, S.; Han, E.S.; Yi, N.-J.; Suh, K.-S. Laparoscopic donor and recipient hepatectomy followed by robot-assisted liver graft implantation in living donor liver transplantation. *Am. J. Transplant. Off. J. Am. Soc. Transplant. Am. Soc. Transpl. Surg.* **2022**, *22*, 1230–1235. [CrossRef]
67. Kim, J.C.; Hong, S.K.; Lee, K.; Lee, S.; Suh, S.; Hong, S.Y.; Han, E.S.; Choi, Y.; Yi, N.; Suh, K. Early experiences with developing techniques for pure laparoscopic explant hepatectomy in living donor liver transplantation. *Liver Transplant.* **2022**, *29*, 377–387. [CrossRef]
68. Dokmak, S.; Cauchy, F.; Aussilhou, B.; Dondero, F.; Sepulveda, A.; Roux, O.; Francoz, C.; Hentic, O.; de Mestier, L.; Levy, P.; et al. Laparoscopic-assisted liver transplantation: A realistic perspective. *Am. J. Transplant. Off. J. Am. Soc. Transplant. Am. Soc. Transpl. Surg.* **2022**, *22*, 3069–3077. [CrossRef]
69. Eguchi, S.; Takatsuki, M.; Soyama, A.; Hidaka, M.; Tomonaga, T.; Muraoka, I.; Kanematsu, T. Elective living donor liver transplantation by hybrid hand-assisted laparoscopic surgery and short upper midline laparotomy. *Surgery* **2011**, *150*, 1002–1005. [CrossRef]
70. Feng, Z.; Wang, S.P.; Wang, H.H.; Lu, Q.; Qiao, W.; Wang, K.L.; Ding, H.F.; Wang, Y.; Wang, R.F.; Shi, A.H.; et al. Magnetic-assisted laparoscopic liver transplantation in swine. *Hepatobiliary Pancreat. Dis. Int. HBPD INT* **2022**, *21*, 340–346. [CrossRef]
71. Hendi, M.; Lv, J.; Cai, X.-J. Current status of laparoscopic hepatectomy for the treatment of hepatocellular carcinoma: A systematic literature review. *Medicine* **2021**, *100*, e27826. [CrossRef]
72. Palanisamy, S.; Sabnis, S.C.; Patel, N.D.; Nalankilli, V.P.; Vijai, A.; Palanivelu, P.; Ramkrishnan, P.; Chinnusamy, P. Laparoscopic Major Hepatectomy-Technique and Outcomes. *J. Gastrointest. Surg. Off. J. Soc. Surg. Aliment. Tract* **2015**, *19*, 2215–2222. [CrossRef]
73. Valente, R.; Sutcliffe, R.; Levesque, E.; Costa, M.; De' Angelis, N.; Tayar, C.; Cherqui, D.; Laurent, A. Fully laparoscopic left hepatectomy—A technical reference proposed for standard practice compared to the open approach: A retrospective propensity score model. *HPB* **2018**, *20*, 347–355. [CrossRef]
74. Piardi, T.; Lhuaire, M.; Memeo, R.; Pessaux, P.; Kianmanesh, R.; Sommacale, D. Laparoscopic Pringle maneuver: How we do it? *Hepatobiliary Surg. Nutr.* **2016**, *5*, 345–349. [CrossRef]
75. Kwak, B.J.; Choi, H.J.; You, Y.K.; Kim, D.G.; Hong, T.H. Laparoscopic end-to-end biliary reconstruction with T-tube for transected bile duct injury during laparoscopic cholecystectomy. *Ann. Surg. Treat. Res.* **2019**, *96*, 319–325. [CrossRef]
76. Kim, S.H.; Lee, K.-W.; Kim, Y.-K.; Cho, S.Y.; Han, S.-S.; Park, S.-J. Tailored telescopic reconstruction of the bile duct in living donor liver transplantation. *Liver Transplant. Off. Publ. Am. Assoc. Study Liver Dis. Int. Liver Transplant. Soc.* **2010**, *16*, 1069–1074. [CrossRef]

77. Parikh, A.; Washburn, K.W.; Matsuoka, L.; Pandit, U.; Kim, J.E.; Almeda, J.; Mora-Esteves, C.; Halff, G.; Genyk, Y.; Holland, B.; et al. A multicenter study of 30 days complications after deceased donor liver transplantation in the model for end-stage liver disease score era. *Liver Transplant. Off. Publ. Am. Assoc. Study Liver Dis. Int. Liver Transplant. Soc.* **2015**, *21*, 1160–1168. [CrossRef]
78. Yang, L.S.; Shan, L.L.; Saxena, A.; Morris, D.L. Liver transplantation: A systematic review of long-term quality of life. *Liver Int.* **2014**, *34*, 1298–1313. [CrossRef]
79. Hou, Y.; Wang, X.; Yang, H.; Zhong, S. Survival and complication of liver transplantation in infants: A systematic review and meta-analysis. *Front. Pediatr.* **2021**, *9*, 628771. [CrossRef]
80. Wu, C.; Lu, C.; Xu, C. Short-term and long-term outcomes of liver transplantation using moderately and severely steatotic donor livers: A systematic review. *Medicine* **2018**, *97*, e12026. [CrossRef]
81. Aydın, O.; Turan Gökçe, D.; Öter, V.; Arı, D.; Özgün, Y.M.; Pişkin, E.; Çolakoğlu, M.K.; Akdoğan Kayhan, M.; Bostancı, E.B. Biliary Complications in Living Liver Donors After Donor Hepatectomy: A Single-Center Experience. *Exp. Clin. Transplant. Off. J. Middle East Soc. Organ Transplant.* **2023**, *21*, 139–142. [CrossRef]
82. Manay, P.; Seth, A.; Jackson, K.; Lentine, K.L.; Schnitzler, M.A.; Xiao, H.; Segev, D.L.; Axelrod, D.A. Biliary Complications After Liver Transplantation in the United States: Changing Trends and Economic Implications. *Transplantation* **2023**, *107*, e127–e138. [CrossRef] [PubMed]
83. Bloom, P.P.; Gilbert, T.; Santos-Parker, K.; Memel, Z.; Przybyszewski, E.; Bethea, E.; Sonnenday, C.J.; Tapper, E.B.; Waits, S. The incidence and natural history of ascites after liver transplantation. *Hepatol. Commun.* **2023**, *7*, e0158. [CrossRef]
84. Hayashi, H.; Takamura, H.; Ohbatake, Y.; Shoji, M.; Nakanuma, S.; Nakagawara, H.; Miyashita, T.; Tajima, H.; Kitagawa, H.; Tani, T.; et al. Internal hernia in a liver transplant recipien: A case report. *Case Rep. Surg.* **2013**, *2013*, 923647. [CrossRef] [PubMed]
85. Kyaw, L.; Lai, N.M.; Iyer, S.G.; Loh, D.S.K.L.; Loh, S.E.K.; Mali, V.P. Percutaneous transhepatic interventional therapy of portal vein stenosis in paediatric liver transplantation: A systematic review of efficacy and safety. *Pediatr. Transplant.* **2022**, *26*, e14187. [CrossRef] [PubMed]
86. Canakis, A.; Gilman, A.J.; Baron, T.H. Management of biliary complications in liver transplant recipients using a fully covered self-expandable metal stent with antimigration features. *Minerva Gastroenterol.* **2023**. [CrossRef]
87. Sepulveda, A.; Brustia, R.; Perdigao, F.; Soubrane, O.; Scatton, O. Pure laparoscopic management of early biliary leakage after liver transplantation: Abdominal lavage and T-Tube placement. *Liver Transplant.* **2015**, *21*, 1105–1106. [CrossRef]
88. Hawksworth, J.; Radkani, P.; Nguyen, B.; Aguirre, O.; Winslow, E.; Kroemer, A.; Girlanda, R.; Guerra, J.F.; Haddad, N.; Fishbein, T. Robotic Hepaticojejunostomy for Late Anastomotic Biliary Stricture After Liver Transplantation: Technical Description and Case Series. *Ann. Surg.* **2022**, *275*, e801–e803. [CrossRef]
89. Lopez-Lopez, V.; Ruiz-Manzanera, J.J.; Eshmuminov, D.; Lehmann, K.; Schneider, M.; von der Groeben, M.; de Angulo, D.R.; Gajownik, U.; Pons, J.A.; Sánchez-Bueno, F.; et al. Are We Ready for Bariatric Surgery in a Liver Transplant Program? A Meta-Analysis. *Obes. Surg.* **2021**, *31*, 1214–1222. [CrossRef]
90. Pedano, N.; Rotellar, F.; Alvarez-Cienfuegos, J.; Arredondo, J.; Bellver, M.; Martínez, P.; Sánchez, C.; Martí, P.; Zozaya, G.; Herrero, J.I.; et al. Efficacy of laparoscopic approach in the management of early liver transplant complications. *Transplant. Proc.* **2012**, *44*, 1560–1561. [CrossRef]
91. Merenda, R.; Gerunda, G.E.; Neri, D.; Barbazza, F.; Di Marzio, E.; Meduri, F.; Valmasoni, M.; Faccioli, A.M. Laparoscopic surgery after orthotopic liver transplantation. *Liver Transplant.* **2000**, *6*, 104–107. [CrossRef]
92. Cascales Campos, P.; Ramírez Romero, P.; González, R.; Pons, J.A.; Miras, M.; Sanchez Bueno, F.; Robles, R.; Parrilla, P. Laparoscopic treatment of biliary peritonitis after removal of T-tube in liver transplant patients. *Transplant. Proc.* **2012**, *44*, 1550–1553. [CrossRef]
93. Soubrane, O.; Cherqui, D.; Scatton, O.; Stenard, F.; Bernard, D.; Branchereau, S.; Martelli, H.; Gauthier, F. Laparoscopic left lateral sectionectomy in living donors: Safety and reproducibility of the technique in a single center. *Ann. Surg.* **2006**, *244*, 815–820. [CrossRef]
94. Koffron, A.J.; Kung, R.; Baker, T.; Fryer, J.; Clark, L.; Abecassis, M. Laparoscopic-assisted right lobe donor hepatectomy. *Am. J. Transplant. Off. J. Am. Soc. Transplant. Am. Soc. Transpl. Surg.* **2006**, *6*, 2522–2525. [CrossRef] [PubMed]
95. Kumar, U.; Gill, I.S. Learning curve in human laparoscopic surgery. *Curr. Urol. Rep.* **2006**, *7*, 120–124. [CrossRef] [PubMed]
96. Brian, R.; Davis, G.; Park, K.M.; Alseidi, A. Evolution of laparoscopic education and the Laparoscopic Learning Curve: A review of the literature. *Laparosc. Surg.* **2022**, *6*, 34. [CrossRef]
97. Wakabayashi, G.; Cherqui, D.; Geller, D.A.; Buell, J.F.; Kaneko, H.; Han, H.S.; Asbun, H.; O'Rourke, N.; Tanabe, M.; Koffron, A.J.; et al. Recommendations for laparoscopic liver resection: A report from the second international consensus conference held in Morioka. *Ann. Surg.* **2015**, *261*, 619–629. [CrossRef]
98. Abu Hilal, M.; Aldrighetti, L.; Dagher, I.; Edwin, B.; Troisi, R.I.; Alikhanov, R.; Aroori, S.; Belli, G.; Besselink, M.; Briceno, J.; et al. The Southampton Consensus Guidelines for Laparoscopic Liver Surgery: From Indication to Implementation. *Ann. Surg.* **2018**, *268*, 11–18. [CrossRef]
99. European Training Requirements for the Specialty of General Surgery—UEMS. 2013. Available online: www.uems.eu/__data/assets/pdf_file/0018/152604/UEMS-2021.35-European-Training-Requirements-in-General-Surgery.pdf (accessed on 10 December 2023).
100. Pulijala, Y.; Ma, M.; Pears, M.; Peebles, D.; Ayoub, A. Effectiveness of Immersive Virtual Reality in Surgical Training-A Randomized Control Trial. *J. Oral Maxillofac. Surg. Off. J. Am. Assoc. Oral Maxillofac. Surg.* **2018**, *76*, 1065–1072. [CrossRef]

101. Cizmic, A.; Müller, F.; Wise, P.A.; Häberle, F.; Gabel, F.; Kowalewski, K.F.; Bintintan, V.; Müller-Stich, B.P.; Nickel, F. Telestration with augmented reality improves the performance of the first ten ex vivo porcine laparoscopic cholecystectomies: A randomized controlled study. *Surg. Endosc.* **2023**, *37*, 7839–7848. [CrossRef]
102. Sheik-Ali, S.; Edgcombe, H.; Paton, C. Next-generation Virtual and Augmented Reality in Surgical Education: A Narrative Review. *Surg. Technol. Int.* **2019**, *35*, 27–35.
103. Marutani, T.; Kato, T.; Tagawa, K.; Tanaka, H.T.; Komori, M.; Kurumi, Y.; Morikawa, S. Active and Passive Haptic Training Approaches in VR Laparoscopic Surgery Training. *Stud. Health Technol. Inform.* **2016**, *220*, 215–218.
104. Huber, T.; Wunderling, T.; Paschold, M.; Lang, H.; Kneist, W.; Hansen, C. Highly immersive virtual reality laparoscopy simulation: Development and future aspects. *Int. J. Comput. Assist. Radiol. Surg.* **2018**, *13*, 281–290. [CrossRef]
105. Silva-Velazco, J.; Dietz, D.W.; Stocchi, L.; Costedio, M.; Gorgun, E.; Kalady, M.F.; Kessler, H.; Lavery, I.C.; Remzi, F.H. Considering Value in Rectal Cancer Surgery: An Analysis of Costs and Outcomes Based on the Open, Laparoscopic, and Robotic Approach for Proctectomy. *Ann. Surg.* **2017**, *265*, 960–968. [CrossRef]
106. Gehrman, J.; Björholt, I.; Angenete, E.; Andersson, J.; Bonjer, J.; Haglind, E. Health economic analysis of costs of laparoscopic and open surgery for rectal cancer within a randomized trial (COLOR II). *Surg. Endosc.* **2017**, *31*, 1225–1234. [CrossRef]
107. Pellegrino, A.; Damiani, G.R.; Fachechi, G.; Corso, S.; Pirovano, C.; Trio, C.; Villa, M.; Turoli, D.; Youssef, A. Cost analysis of minimally invasive hysterectomy vs open approach performed by a single surgeon in an Italian center. *J. Robot. Surg.* **2017**, *11*, 115–121. [CrossRef]
108. Govaert, J.A.; Fiocco, M.; van Dijk, W.A.; Kolfschoten, N.E.; Prins, H.A.; Dekker, J.W.T.; Tollenaar, R.A.E.M.; Tanis, P.J.; Wouters, M.W.J.M.; Dutch Value Based Healthcare Study Group. Multicenter Stratified Comparison of Hospital Costs Between Laparoscopic and Open Colorectal Cancer Resections: Influence of Tumor Location and Operative Risk. *Ann. Surg.* **2017**, *266*, 1021–1028. [CrossRef]
109. Ayvazoglu Soy, E.H.; Kirnap, M.; Yildirim, S.; Moray, G.; Haberal, M. Incisional Hernia After Liver Transplant. *Exp. Clin. Transplant. Off. J. Middle East Soc. Organ Transplant.* **2017**, *15* (Suppl. 1), 185–189. [CrossRef]
110. Cos, H.; Ahmed, O.; Garcia-Aroz, S.; Vachharajani, N.; Shenoy, S.; Wellen, J.R.; Doyle, M.M.; Chapman, W.C.; Khan, A.S. Incisional hernia after liver transplantation: Risk factors, management strategies and long-term outcomes of a cohort study. *Int. J. Surg.* **2020**, *78*, 149–153. [CrossRef]
111. Frountzas, M.; Nikolaou, C.; Maris, S.; Stavrou, E.; Giannopoulos, P.; Schizas, D.; Stergios, K.; Toutouzas, K. Open or laparoscopic mesh repair of incisional hernia in patients that underwent liver transplantation: A systematic review and proportional meta-analysis. *Clin. Transplant.* **2020**, *34*, e14103. [CrossRef]
112. Mekeel, K.; Mulligan, D.; Reddy, K.S.; Moss, A.; Harold, K. Laparoscopic incisional hernia repair after liver transplantation. *Liver Transplant.* **2007**, *13*, 1576–1581. [CrossRef]
113. Kennealey, P.T.; Johnson, C.S.; Tector, A.J., 3rd; Selzer, D.J. Laparoscopic incisional hernia repair after solid-organ transplantation. *Arch. Surg.* **2009**, *144*, 228–233, discussion 233. [CrossRef]
114. Scheuerlein, H.; Rauchfuss, F.; Gharbi, A.; Heise, M.; Settmacher, U. Laparoscopic incisional hernia repair after solid-organ transplantation. *Transplant. Proc.* **2011**, *43*, 1783–1789. [CrossRef] [PubMed]
115. Gianchandani, R.; Pérez, E.; Moneva, E.; Menéndez, A.; Sánchez, J.M.; Díaz, C.; Concepción, V.; Barrera, M.A. Laparoscopic Incisional Hernia Repair After Liver Transplantation: Long-Term Series and Literature Review. *Transplant. Proc.* **2020**, *52*, 1514–1517. [CrossRef] [PubMed]
116. Kurmann, A.; Beldi, G.; Vorburger, S.A.; Seiler, C.A.; Candinas, D. Laparoscopic incisional hernia repair is feasible and safe after liver transplantation. *Surg. Endosc.* **2010**, *24*, 1451–1455. [CrossRef] [PubMed]
117. Ealing, I.V.; Lau, N.S.; Cheung, D.; Peruch, S.; Agostinho, N.; Crawford, M.; Pulitano, C. Safety of laparoscopic repair of incisional hernias in liver transplant recipients. *Clin. Transplant.* **2023**, *37*, e14969. [CrossRef]
118. Han, G.R.; Johnson, E.R.; Jogerst, K.M.; Calderon, E.; Hewitt, W.R.; Pearson, D.G.; Harold, K.L. Outcomes of a Large Series of Laparoscopic Ventral Hernia Repairs after Liver Transplantation. *Am. Surg.* **2023**, 31348231156762. [CrossRef] [PubMed]
119. Hegab, B.; Abdelfattah, M.R.; Azzam, A.; Al Sebayel, M. The usefulness of laparoscopic hernia repair in the management of incisional hernia following liver transplantation. *J. Minimal Access Surg.* **2016**, *12*, 58–62. [CrossRef]
120. Weiss, S.; Weissenbacher, A.; Sucher, R.; Denecke, C.; Brandl, A.; Messner, F.; Oellinger, R.; Schneeberger, S.; Schmid, T.; Pratschke, J.; et al. Outcome analysis of laparoscopic incisional hernia repair and risk factors for hernia recurrence in liver transplant patients. *Clin. Transplant.* **2015**, *29*, 866–871. [CrossRef] [PubMed]
121. Ratti, F.; Cipriani, F.; Fiorentini, G.; Catena, M.; Paganelli, M.; Aldrighetti, L. Reappraisal of the advantages of laparoscopic liver resection for intermediate hepatocellular carcinoma within a stage migration perspective: Propensity score analysis of the differential benefit. *J. Hepato-Biliary-Pancreat. Sci.* **2020**, *27*, 510–521. [CrossRef]
122. Baek, H.; Cho, M.; Kim, S.; Hwang, H.; Song, M.; Yoo, S. Analysis of length of hospital stay using electronic health records: A statistical and data mining approach. *PLoS ONE* **2018**, *13*, e0195901. [CrossRef]
123. Ee, W.W.; Lau, W.L.; Yeo, W.; Von Bing, Y.; Yue, W.M. Does minimally invasive surgery have a lower risk of surgical site infections compared with open spinal surgery? *Clin. Orthop. Relat. Res.* **2014**, *472*, 1718–1724. [CrossRef] [PubMed]
124. Finotti, M.; D'Amico, F.; Mulligan, D.; Testa, G. A narrative review of the current and future role of robotic surgery in liver surgery and transplantation. *Hepatobiliary Surg. Nutr.* **2023**, *12*, 56–68. [CrossRef] [PubMed]

125. Yang, J.D.; Lee, K.W.; Kim, J.M.; Kim, M.S.; Lee, J.G.; Kang, K.J.; Choi, D.L.; Kim, B.W.; Ryu, J.H.; Kim, D.S.; et al. A comparative study of postoperative outcomes between minimally invasive living donor hepatectomy and open living donor hepatectomy: The Korean Organ Transplantation Registry. *Surgery* **2021**, *170*, 271–276. [CrossRef] [PubMed]
126. Albayati, S.; Hitos, K.; Berney, C.R.; Morgan, M.J.; Pathma-Nathan, N.; El-Khoury, T.; Richardson, A.; Chu, D.I.; Cannon, J.; Kennedy, G.; et al. Robotic-assisted versus laparoscopic rectal surgery in obese and morbidly obese patients: ACS-NSQIP analysis. *J. Robot. Surg.* **2023**, *17*, 637–643. [CrossRef]