Incisional hernia formation in hepatobiliary surgery using transverse and hybrid incisions: a systematic review and meta-analysis

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ABSTRACT

INTRODUCTION Evidence suggests that midline incisions should be closed with the small-bite technique to reduce IH formation. No recommendations exist for the closure of transverse incisions used in hepatobiliary surgery. This work systematically summarises rates of IH formation and associated technical factors for these transverse incisions.

METHODS A systematic search was undertaken. Studies describing the incidence of IH were included. Incisions were classified as transverse (two incision types) or hybrid (transverse with midline extension, comprising five incision types). The primary outcome measure was the pooled proportion of IH. Subgroup analysis based on minimum follow-up of two years and a priori definition of IH with clinical and radiological diagnosis was undertaken.

FINDINGS Thirteen studies were identified and included 5,427 patients; 1,427 patients (26.3%) underwent surgery for benign conditions, 3,465 (63.8%) for malignancy and 535 (9.9%) for conditions that were not stated or classified as 'other'. The pooled incidence of IH was 6.0% (2.0–10.0%) at a weighted mean follow-up of 17.5 months in the transverse group, compared with 15.0% (11.0–19.0%) at a weighted mean follow-up of 42.0 months in the hybrid group ($p = 0.045$). Subgroup analysis did not demonstrate a statistical difference in IH formation between the hybrid versus transverse groups.

CONCLUSION Owing to the limitations in study design and heterogeneity, there is limited evidence to guide incision choice and methods of closure in hepatopancreatobiliary surgery. There is an urgent need for a high-quality prospective cohort study to understand the techniques used and their outcomes, to inform future research.

KEYWORDS

Incisional hernia – Pancreas – Liver – Subcostal – Transplant

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Introduction

The development of an incisional hernia (IH) is a common postoperative complication following open abdominal surgery with an incidence of up to 40% in high-risk groups.^{1,2} Incisional hernias reflect a significant problem for patients who may present with symptoms including pain, limitation of daily activities, cosmetic complaints, skin problems or incarceration with or without strangulation of the hernia content.³ Exact figures regarding IH development are unknown due to the lack of a standardised definition, subjectivity of clinical examination, a lack of prospective data and the short follow-up periods used in most studies. It is estimated that 10,000 IH

repairs are performed in the UK each year, representing a significant burden on health care services.² Some technical and non-technical factors are known to predispose to IH development. However, there is uncertainty regarding technical risk factors and IH formation, particularly in transverse incisions.

Known patient-related risk factors include obesity, diabetes mellitus, increasing age, steroid use and smoking.^{4,5} Technical risk factors for IH development have predominantly been investigated in midline incisions with emerging evidence that small-bite closure with long-lasting monofilament suture material reduces the incidence of IH formation.^{6–8} However, there is no consensus regarding the optimum method

of wound closure for transverse incisions. Additionally, various incisions are used in hepatopancreatobiliary (HPB) surgery including transverse (Kocher's/right subcostal) and hybrid incisions with vertical midline extensions (extended right subcostal, J, reverse L and a Mercedes-Benz incision; Fig 1).⁹ In view of the paucity of evidence regarding the optimal incision, the choice of incision is likely to be dependent on perceived ease of access to the operative field and surgeon preference. A Cochrane review conducted over a decade ago suggested that there were no significant differences in clinical outcomes between transverse and midline incisions and that the choice of incision should be based on surgeon choice.¹⁰ However, the included studies were at significant risk of methodological bias with most having follow-up periods of less than one year and many conducted outside the field of HPB surgery. No recommendations currently exist regarding wound creation and closure techniques for HPB surgery.

Therefore, this paper compares IH rates between transverse and hybrid incisions in HPB surgery and to assess which technical factors may be associated with subsequent hernia formation.

Methods

A comprehensive systematic search of the literature was performed in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analysis guidelines.¹¹ The protocol was registered with the international prospective register for systematic reviews (PROSPERO – CRD42018086716). PubMed, Embase (since 1980), MEDLINE, Google Scholar, CENTRAL, CINNAHL and the Cochrane Library were searched using the following MeSH search terms 'IH', 'incision', 'Kocher's', 'right upper quadrant', 'reverse L', 'reverse T', 'subcostal', 'bilateral subcostal', 'reverse J', 'Whipples', 'pancreas transplant', 'pancreatic transplant', 'liver transplant', 'pancreaticoduodenectomy'; terms were combined using 'and/or' as appropriate (Appendix 1). Variations in hyphenation were also included. Bibliographies of relevant studies and the 'related articles' link in PubMed

were used to identify additional studies. The search was updated on 31 December 2019. The search was conducted independently by two authors (SRD and SP).

Inclusion criteria

All studies were included where patients were undergoing HPB resection, liver transplantation or open cholecystectomy and the incidence of IH was reported. Both comparative and non-comparative studies were included. Studies included adults over the age of 18 years and were published in the English language. Studies were carefully evaluated for duplication or overlapping data and where institutions had published two studies either the most recent or best quality data set was included.

Exclusion criteria

Studies were excluded if they described closure with catgut, did not detail the closure technique or used prophylactic mesh. Studies employing closure with catgut were excluded since this material has been superseded by synthetic alternatives and was banned for human use due to concerns about the transmission of bovine spongiform encephalopathy in the mid-nineties.¹² Studies describing prophylactic mesh placement were also excluded as there is emerging evidence to support mesh placement in high-risk patients undergoing midline laparotomy.¹³ Animal studies, letters, reports and conference abstracts were also excluded.

Definitions

Transverse incisions include a Kocher's/right subcostal and a rooftop incision. Hybrid incisions, with a cranial or caudal midline extension, include the extended right subcostal, Mercedes-Benz incision, J-shaped incision, reverse L, reverse T incision and right transverse with vertical extension (Fig 1).

Currently, there is no standardised investigative modality to diagnose an IH. Clinical examination alone fails to detect up to one-third of hernias.¹⁴ Data were therefore collected regarding how IH was defined and reported

across studies to investigate current practice. Surgical site infections were defined as superficial incisional, deep incisional or organ space infections in accordance with the US Centers for Disease Control and Prevention definition.¹⁵ Wound dehiscence was defined as the separation of wound edges either superficially or in the deep layer.¹⁶

Outcome measures

The primary outcome measure was the pooled incidence of IH, expressed as a proportion of total cases. Subgroup analysis for included studies was undertaken using predefined endpoints: a) minimum of two years follow-up; and b) a priori definition of recurrence with radiological and clinical confirmation of IH. Weighted mean follow-up based on the number of patients included in each study was calculated for the entire cohort of studies included in the review, as well as for the hybrid and transverse groups.

Secondary outcome measures were IH by suture type and method of closure (one or two layered), surgical site infection and wound dehiscence. Although wound dehiscence is usually considered a technical failure, the authors considered that it was valuable to include because dehiscence may reflect a more difficult closure. Data were also collected regarding how IH was defined and reported across studies.

Study selection

Two authors (SRD and SP) independently assessed the search results, undertaking a title screen followed by abstract review, then full text review of potentially eligible studies. Any discrepancies were sent to a third author (NJS) for additional review and resolution. Publications satisfying the exclusion criteria were discarded at each stage. Publications without abstracts directly underwent full text review.

Data extraction

Data extraction was undertaken independently by authors SRD and NR. Any discrepancies were discussed between the authors and escalated to the senior author (SP) for adjudication when necessary. Where present, relevant secondary outcomes were extracted from the studies.

Quality assessment

The quality of all studies was analysed using the Methodological Index for Non-Randomised Studies (MINORS) to establish quality of the study and risk of bias.¹⁷ Each study was analysed against the criteria by two separate authors (SRD and NR) and an average score was calculated. For non-comparative studies, a maximum score of 16 could be achieved using the tool, with a maximum score of 24 available for comparative studies. Any discrepancies were resolved by consensus or escalation to a third author (SP). Randomised control trials were assessed using the Cochrane risk of bias tool by the same two authors.^{17,18}

Statistical analysis

Data were presented as frequencies and percentages. Comparative analyses were performed using the Mann-Whitney

U and chi-square tests as appropriate. Weighted pooled proportions with 95% confidence intervals (CI) using the random effects (DerSimonian and Laird) model were calculated for IH formation due to the high level of between-study heterogeneity. A meta-regression was undertaken to determine the effect of incision type (transverse or hybrid) on IH formation. All the statistical analyses were performed using Stata version 13.0.

Findings

The search returned 109 articles of which 55 relevant abstracts were identified for further review. Three papers were identified from reference list reviews. After exclusions, 25 articles remained for full-text review, with 13 included in the systematic review (Fig 2). Our findings suggest that transverse incisions may be associated with a lower rate of IH development than incisions with a vertical midline extension although when more robust endpoints were used there was no difference in the incidence of IH. The findings should be interpreted with caution as the transverse group had much lower numbers and a shorter duration of follow-up.

Study characteristics

The 13 studies were performed in 11 countries and included a total of 5,427 patients; 1,427 patients (26.3%) underwent surgery for benign conditions, 3,465 (63.8%) for malignancy and 535 (9.9%) for conditions that were not stated or were classified as 'other' (Table 1). Two studies were randomised controlled trials,^{18,19} five were prospective cohort studies^{20–24} and six were retrospective cohort studies.^{25–30} Four of the 11 non-randomised studies were comparative in nature.^{20–22,27} The number of patients included in each study ranged from 26 to 1,426. Where sex was stated or could be extracted from subgroups, 2,732 patients were male (54.8%). Where stated, no differences were identified between patients undergoing surgery through different incision types. The weighted mean follow-up time across all studies included in the review was 38 months.

Primary outcome

The pooled incidence of IH for the hybrid group ($n = 4,087$) was 15.0% (95% CI 11–19%) at a weighted mean follow-up of 42.0 months and 6.0% (95% CI 2–10%) at a weighted mean follow-up of 17.5 months for the transverse group ($n = 397$), $p = 0.045$ (Fig 3). When studies reporting a minimum of two-year follow-up were analysed, the pooled incidence of IH in the hybrid ($n = 1,763$) and transverse groups ($n = 192$) were comparable (14% vs 9%, $p = 0.251$). An additional sensitivity analysis that only included studies providing an a priori definition of recurrence with combined clinical and radiological identification of IH also revealed no difference in the incidence of IHs between the hybrid ($n = 1,382$) and transverse groups ($n = 166$) (14% vs 9%, $p = 0.798$).

Secondary outcomes

Pooled analysis of the secondary outcome measures reported below was not feasible due to the low number of studies included in each sub-group and thus the incidence of IH was quoted as a range.

a) Suture type: overall, IH by suture type where stated, varied from 0% to 31.3% with slowly absorbable sutures (polydioxanone [PDS], Monomax and Vicryl) and 5.7–10.1% with non-absorbable types (Prolene and silk) (Table 2).

b) Method of closure: the method for closing the abdominal wall varied considerably (Table 2). The incidence of IH by closure technique ranged from 5.8% to 24% for single layer ($n = 1,673$) and from 0–31.3% for the two-layer closure method ($n = 2,070$).

c) SSI and wound dehiscence: only one study classified surgical site infections using Centers for Disease Control and Prevention criteria.³⁰ Surgical site infections were reported by nine studies but only defined in four,^{17,19,26,29} thus preventing any meaningful analysis. Four studies reported wound dehiscence but only two studies defined it as a priori.^{19,25} Wound dehiscence varied between 0.4% and 5.0%.^{18,20,24,29}

d) Mode of diagnosis: the modalities used to diagnose IH varied across studies. Incisional hernia was diagnosed using a combination of clinical and radiological methods (where clinical examination was equivocal) in seven studies.^{5,25,24,26,27,29,30} Five studies used clinical examination alone;^{18,19,21,22,25} one diagnosed IH based on information in the medical records.²⁰

Figure 2 PRISMA flow chart

Quality assessment

There were methodological weaknesses across all the studies (Table 1; Fig 4). Loss to follow-up for most studies exceeded 5%, which is the suggested maximum acceptable value compatible with a high-quality study using the MINORS criteria. No studies reported that the outcome assessors were blind to the type of incision used.

Discussion

Any abdominal incision can cause pain, wound-related problems or IHS in the long-term. There is a paucity of evidence regarding wound related complications in HPB surgery and therefore surgeons continue to use different

incisions to perform the same operation. The aim was to identify IH incidence in HPB surgery and technical factors that may prevent hernia development. Our findings suggest that transverse incisions may be associated with a lower rate of IH development than incisions with a vertical midline extension, although when more robust endpoints were used there was no difference in the incidence of IH.

There is a lack of consensus regarding optimal closure of abdominal incisions per se. Some technical factors regarding midline abdominal incisions have previously been investigated. European Hernia Society guidelines for closing midline incisions recommend the small-bite technique for midline closure, following evidence from a well-designed and conducted randomised controlled trials.^{6,7} The INLINE systematic review suggests that a continuous closure with

Table 1 Study characteristics

Study	Country of origin	Study design	Type of incision	Indications	Participants (n)	MINORS score
Dorfman <i>et al</i> (1997) ¹⁸	Venezuela	RCT	Kocher's (RSC)	Cholecystectomy	129	n/a
Sanz-López <i>et al</i> (1999) ²⁵	Spain	Retrospective	RSC	Cholecystectomy	26	5/16
D'Angelica <i>et al</i> (2006) ²⁰	USA	Prospective comparative	Mercedes vs ERSC	930 (CRLM) 177 (HCC) 189 (other metastatic) 130 (benign)	856 (Mercedes) 570 (ERSC)	15/24
Togo <i>et al</i> (2008) ³⁰	Japan	Retrospective	Median vs J incision vs RTVE incision vs reverse T	263 (HCC) 315 (CRLM) 48 (other)	95 (median) 233 (J incision) 206 (RTVE) 92 (reverse T)	9/16
Heisterkamp <i>et al</i> (2008) ²¹	Holland	Prospective comparative	J incision vs Mercedes	Liver transplant	60 (J incision) 58 (Mercedes)	16/24
Donatuccio <i>et al</i> (2006) ²²	Italy	Prospective comparative	RSC vs Mercedes vs J incision	Liver transplant	27 (RSC) 11 (Mercedes) 9 (J incision)	11/24
Halm <i>et al</i> (2009) ¹⁹	Holland	RCT	Midline vs RSC	Cholecystectomy	75 (RSC)	n/a
Fikatas <i>et al</i> (2013) ²³	Germany	Prospective	Mercedes	Liver transplant	810	9/16
Nilsson <i>et al</i> (2016) ²⁶	Sweden	Retrospective	ERSC and Mercedes	CRLM	198 (ERSC) 52 (Mercedes)	6/16
Blazquez Hernando <i>et al</i> (2016) ²⁷	Spain	Longitudinal prospective cohort comparative	Bilateral subcostal	11 (gastric cancer) 3 (HCC) 12 (CRLM) 6 (pancreatic cancer) 25 (benign)	57	11/24
Arslan <i>et al</i> (2017) ²⁴	Turkey	Prospective	J incision	Hepatic resection	165	9/16
Lee <i>et al</i> (2019) ²⁸	South Korea	Retrospective	Mercedes	Liver transplant	1,044	8/16
Chen-Xu <i>et al</i> (2019) ²⁹	Portugal	Retrospective	J incision; inverted L; subcostal; transverse	219 (CRLM) 39 (HCC) 41 (cholangiocarcinoma) 65 (pancreatic malignancy) 178 (benign)	419 (J incision) 17 (L incision) 103 (midline) 102 (subcostal) 7 (transverse) 6 (not stated)	9/16

CRLM, colorectal liver metastases; ERSC, extended right subcostal; HCC, hepatocellular carcinoma; RCT, randomised controlled trial; RSC, right subcostal; RTVE, right transverse with vertical extension

slowly absorbable suture material had lower incisional hernia rates in mid-line incisions.⁸ However, the INSECT trial found no difference between suture types.³² Our findings suggest lower IH rates with non-absorbable sutures but the numbers included are small. Other technical factors which may influence IH formation include length of suture material and type of needle used in closure.³³ Uncertainty remains regarding which factors predispose to IH formation in midline incisions. However, there is greater uncertainty regarding non-midline incisions with some studies suggesting a reduced incidence of IH formation when transverse incisions are used.^{34–37} However, a previous Cochrane review and the POVATI trial demonstrated no difference in IH rates between midline and transverse incisions and concluded that the incision should be based on surgeon preference.^{10,58} This may explain why there is variation in the types of incision employed by HPB surgeons to perform the same procedure. Furthermore, there is also variation in how these incisions are closed (by suture type and mass vs layered closure).

The findings from this review need to be interpreted with caution. Most of the included studies had significant methodological weaknesses. Eleven of these were non-randomised studies and therefore subject to inherent biases. There were variations across studies regarding the definitions of IH, surgical site infections, wound dehiscence and mode of diagnosis of IH. In studies relying on clinical examination alone, the true incidence of IH development may have been underestimated. For instance, smaller, asymptomatic hernias in patients with a higher body mass index may have been missed in patients in the absence of cross-sectional imaging.³¹ It is also difficult to determine whether outcomes were consistently identified and reported across studies due to the heterogeneity in clinical definition. Furthermore, there were significant differences between the included patient populations in terms of the indication for surgery that may impact on the risk of IH formation (ie patients requiring an open cholecystectomy for complex benign disease represented a different patient group to those

Figure 3 Forest plot for the association between incision type and incisional hernia

Table 2 Primary and secondary outcomes								
Study	Incision (n)	Suture material (n)	Type of closure	Incisional hernia		Follow up period (months)	Surgical site infections (%)	Wound dehiscence (%)
				Rate	(%)			
Dorfman <i>et al</i> (1997) ¹⁸	RSC (129)	Vicryl	1 layer continuous	5/129	3.8	12	4.65	2.32
Sanz-López <i>et al</i> (1999) ²⁵	RSC (26)	Vicryl	2-layer: 1st continuous, 2nd interrupted	0	0	24 (minimum)	Not stated	Not stated
D'Angelica <i>et al</i> (2006) ²⁰	Mercedes (856)	PDS	Single layer (2 in cirrhosis)	74/755	9.8	12	14.5	0.8
	ERSC (570)			25/517	4.8		12.3	0.4
Togo <i>et al</i> (2008) ³⁰	Median (95)	Silk (342) Vicryl (284)	2 layers			12 (minimum); 12–168 (range)		Not stated
	J (233)			11/233	4.7		4.1	
	RTVE (206)			11/206	5.4		26.4	
	Reverse T (92)			20/92	21.7		15.0	
Heisterkamp <i>et al</i> (2008) ²¹	J (60)	PDS	Single-layer continuous	4/60	6.7	36 (minimum)	19	Not stated
	Mercedes (58)			14/5	24		3	
Donataccio <i>et al</i> (2006) ²²	RSC (27)	Vicryl	2-layer continuous	2/26	7.7	3	No difference identified	Not stated
	Mercedes & J (20)			6/19	31.3			
Halm <i>et al</i> (2009) ¹⁹	RSC (75)	Vicryl	2-layer: 1st continuous; 2nd interrupted	1/60	1.6	12–16	4	Not stated
Fikatas <i>et al</i> (2013) ²³	Mercedes (810)	PDS	2-layer continuous	77/810	9.5 (median)	6.2–81.8	Not stated	Not stated
Nilsson <i>et al</i> (2016) ²⁶	ERSC (198)	PDS	2-layer continuous	60/198	30.3	2–59	Not stated	Not stated
	Mercedes (52)			16/52	30.7			
Blazquez Hernando <i>et al</i> (2016) ²⁷	Bilateral/rooftop (57)	Monomax	2-layer continuous	10/57	17.54	24	15.79	Not stated
Arslan <i>et al</i> (2017) ²⁴	J (165)	PDS	2-layer, U suture at apex	38/165	23	6–96	7.3	1.21
Lee <i>et al</i> (2019) ²⁸	Mercedes (1,044)	Monofilament and Polysorb	2-layer continuous with interrupted	79/1044	7.6	24–144	Not stated	Not stated
Chen-Xu <i>et al</i> (2019) ²⁹	J incision (419)	PDS (206) Vicryl (40) Monomax (7) Prolene (268)	2 layers (subcostal and transverse); combined: 2 layers on transverse element, with single layer on midline extensions (J and L incisions)	53/419	12.7	0.33–93.77	10.4	5.0
	L incision (17)			3/17	17.7			
	Midline (103)							
	Subcostal (102)			7/102	6.7			
	Transverse (7)			1/7	14.29			
ERSC, extended right subcostal; PDS, polydioxanone; RSC, right subcostal; RTVE, right transverse with vertical extension

undergoing a liver transplant or resection). While contemporary operative management of cholecystectomy has evolved from the open to the laparoscopic approach, the included studies still contribute data on IH formation in HPB surgery. The studies were conducted across 11 countries with variable follow-up periods, thus introducing selection bias. For instance, the shorter weighted mean follow-up of the transverse group compared with the hybrid group could have led to an overestimation of the difference in IH formation between the two groups.

The CIPHER study group (ISRCTN17573805) has similarly identified a large number of technical factors that may contribute to the formation of parastomal hernia.⁵⁹ We advocate a similar approach to IH formation following HPB surgery, which may then inform the design of future randomised controlled trials. In view of the limitations in study design and heterogeneity (of included population and technical factors), there is limited evidence to guide incision choice and methods of closure in HPB surgery. Quantitative and qualitative studies are needed to understand both the size of the variation and reasons for this.

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