

Surgical Safety, Anatomical Variations, and Postoperative Outcomes in Minimally Invasive Abdominal Surgery: An Evidence-Based Narrative Review

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Abstract

Background: Minimally invasive abdominal surgery (MIAS) is now the default approach for cholecystectomy and metabolic–bariatric surgery, yet its safety profile continues to be shaped by three interacting determinants: the surgeon's ability to recognise anatomy through a two-dimensional laparoscopic view, the prevalence of unexpected anatomical variation, and the quality of access-site management at the close of the operation. This review integrates contemporary evidence across these three domains.

Methods: A structured narrative review was conducted of English-language literature indexed in PubMed/MEDLINE, Scopus and Google Scholar up to October 2026, prioritising systematic reviews, meta-analyses, randomised controlled trials (RCTs), large registry-based cohorts and clinically instructive case reports. Evidence was synthesised thematically around (i) extrabiliary landmarks and bile duct injury (BDI), (ii) vascular anatomical variation in the mesenteric–portal system, and (iii) port-site closure, wound outcomes and trocar-site hernia (TSH).

Results: Pooled data from more than 505,000 laparoscopic cholecystectomies place biliary injury at 0.32–0.52%, and 97% of major injuries arise from visual misperception rather than technical error. Across three clinical cohorts (n = 785), Rouvière's sulcus (RS) was identified in 89.6% of patients, and its absence prolongs hepatocystic-triangle dissection. Meta-analytic data show that the superior mesenteric vein (SMV) lacks a common trunk in 7.5% of patients, with further variability in jejunal and gastrocolic tributaries; aberrant SMV drainage has now been documented intraoperatively during sleeve gastrectomy. Portomesenteric venous thrombosis complicates approximately 0.4–0.5% of sleeve gastrectomies. In a 1,655-patient sleeve gastrectomy registry, skin staples were associated with lower superficial surgical site infection than subcuticular sutures (0.77% vs 3.54%; OR 0.21, 95% CI 0.09–0.48), contrasting with abdominal-surgery RCTs that show equivalence or favour sutures. TSH incidence ranges from 0–5.2% in general laparoscopy to a pooled 3.22% in bariatric cohorts, rising markedly with active ultrasound surveillance.

Conclusions: Safety in MIAS depends less on any single manoeuvre than on a phase-linked system: pre-operative anticipation of variants, landmark-anchored intra-operative identification layered on the critical view of safety, and population-specific wound-closure strategies. We propose a three-phase safety framework and identify priority areas for prospective, multicentre research.

Keywords: *Laparoscopic cholecystectomy; Rouvière's sulcus; Bile duct injury; Anatomical variation; Superior mesenteric vein; Sleeve gastrectomy; Port-site closure; Surgical site infection; Trocar-site hernia*

INTRODUCTION

Over the past three decades, minimally invasive abdominal surgery (MIAS) has displaced open surgery as the standard of care for a wide range of benign abdominal conditions. Laparoscopic cholecystectomy (LC) is among the most frequently performed general surgical procedures worldwide, and laparoscopic sleeve gastrectomy (LSG) has been the most commonly performed metabolic–bariatric operation globally since 2014, accounting for 55.4% of the 696,191 procedures reported to the International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) in 2018

and remaining the leading procedure through 2021 (Angrisani *et al.*, 2021, 2024). The physiological advantages of the laparoscopic approach—reduced pain, shorter hospital stay, faster return to function and superior cosmesis—are well established.

These advantages, however, have been purchased at a specific price. The laparoscope removes binocular depth perception and haptic feedback, narrows the operative field, and magnifies distortion caused by inflammation, adiposity and traction. At the beginning of the laparoscopic era, rates of bile duct injury (BDI) increased up to five-fold compared with open cholecystectomy (Pucher *et al.*, 2018). Way *et al.* (2003), analysing 252 major laparoscopic BDIs from a human-factors perspective, demonstrated that the primary cause of error in 97% of cases was a visual perceptual illusion, while faults in technical skill accounted for only 3%. This finding reframed surgical safety in MIAS as fundamentally a problem of recognition, and therefore of anatomy.

Anatomy, however, is not uniform. Textbook configurations of the biliary tree, hepatic arterial supply, and mesenteric–portal venous system describe only the most common pattern, and clinically relevant variants are encountered in a substantial minority of patients (Negoi *et al.*, 2018a, 2018b). When a variant meets a cognitive heuristic in a two-dimensional field, the conditions for misidentification are created. Finally, even technically flawless intra-abdominal surgery can be undermined by complications at the access sites themselves: surgical site infection (SSI), wound dehiscence and trocar-site hernia (TSH) are common, costly and disproportionately prevalent in high-risk populations such as patients with obesity (Karampinis *et al.*, 2019; Ezzi, 2026b).

Recent work has illustrated each of these three determinants with unusual clarity. Ezzi (2026a) examined the clinical utility of Rouvière's sulcus as an extrabiliary landmark for safe and efficient LC in a retrospective cohort; Ezzi (2026c) reported aberrant drainage of the superior mesenteric vein encountered during sleeve gastrectomy; and Ezzi (2026b) compared skin staplers with subcuticular sutures for port-site closure across 1,655 sleeve gastrectomies over four years. Taken together, these studies trace the patient's journey from intra-operative orientation, through anatomical uncertainty, to wound healing. The aim of the present review is to integrate this recent evidence with the wider literature, to quantify the burden of each class of hazard, and to propose a coherent, phase-linked framework for safety in MIAS.

METHODS

Design

This article is a structured narrative review. A narrative rather than a formal meta-analytic design was chosen because the three domains under study differ fundamentally in their evidence base: BDI prevention relies largely on observational cohorts and pooled analyses; vascular anatomical variation is described in cadaveric, radiological, and case-report literature; and wound closure is supported by RCTs and large registries. Reporting was informed by the Scale for the Assessment of Narrative Review Articles (SANRA) criteria.

Search Strategy and Selection

PubMed/MEDLINE, Scopus and Google Scholar were searched for English-language literature published up to October 2026. Search terms combined procedure terms ("laparoscopic cholecystectomy", "sleeve gastrectomy", "laparoscopy", "minimally invasive") with domain terms ("bile duct injury", "critical view of safety", "Rouvière's sulcus", "R4U line", "superior mesenteric vein", "anatomical variation", "Henle trunk", "portomesenteric thrombosis", "skin stapler", "subcuticular suture", "surgical site infection", "trocar site hernia", "port-site"). Reference lists of included articles were hand-searched. Priority was given to (i) systematic reviews and meta-analyses, (ii) RCTs, (iii) registry-based and consecutive cohort studies with at least 100 patients, and (iv) case reports that document previously undescribed variants. Studies were excluded if they were non-English, lacked extractable outcome data, or concerned exclusively open surgery without relevance to minimally invasive practice.

Data Extraction and Synthesis

For each eligible study, the design, sample size, population, principal outcome measure, and effect estimate were extracted. Where studies reported a common proportion (for example, the frequency of Rouvière's sulcus identification), a simple sample-size-weighted pooled estimate was calculated for descriptive purposes; no formal random-effects model was fitted given the heterogeneity of definitions. Effect estimates are reported as presented in the source publications. Evidence was then organised into three thematic domains corresponding to the intra-operative, anatomical and post-operative dimensions of surgical safety.

RESULTS AND EVIDENCE SYNTHESIS

Domain I: Bile Duct Injury and the Role of Extrabiliary Landmarks

Burden of Injury

The most comprehensive contemporary estimate of LC outcomes derives from the SAGES Safe Cholecystectomy Task Force, which pooled 151 studies encompassing 505,292 patients. Overall morbidity, biliary injury, and mortality rates were 1.6–5.3%, 0.32–0.52%, and 0.08–0.14%, respectively; among studies reporting severity, major duct injury occurred in 0.28% and bile leak in 0.46% (Pucher *et al.*, 2018). Encouragingly, reported BDI rates declined from 0.69% in 1994–1999 to 0.22% in 2010–2015, but the authors noted marked heterogeneity in reporting and called for international outcome registries. Although uncommon, BDI carries disproportionate consequences: Flum *et al.* (2003) showed in a Medicare population that BDI was associated with a significant reduction in long-term survival, and injury remains among the most frequently litigated complications in general surgery.

Table 1: Frequency of Rouvière's sulcus identification and associated outcomes in selected studies.

Study	Design / setting	n	RS identified	Principal findings
Pathak *et al.* (2023)	Retrospective observational, India	500	465 (93.0%)	Open type most common (75.3%); no BDI when CVS was achieved antero-superior to RS; mean operative time 46.3 min
Bandaru *et al.* (2026)	Longitudinal observational, UAE (elective and emergency LC)	130	111 (85.4%)	RS absence prolonged CVS dissection (median 20 vs 18 min; P = .030); no effect on complications
Dawoud *et al.* (2024)	Prospective, Egypt	155	127 (81.9%)	Absent RS associated with longer hospital stay and operative time (P < .001 and P = .008)
Ezzi (2026a)	Retrospective cohort	—	—	RS supports safe and efficient LC as an extrabiliary orientation landmark
Pooled clinical estimate*	3 cohorts	785	703 (89.6%)	Approximately 1 patient in 10 lacks a visible sulcus

RS, Rouvière's sulcus; BDI, bile duct injury; CVS, critical view of safety; LC, laparoscopic cholecystectomy.
*Sample-size-weighted descriptive estimate calculated by the authors from the three clinical cohorts with extractable counts.
The Bandaru *et al.* count was derived from the reported percentage.

Why Injuries Occur

The landmark analysis by Way *et al.* (2003) established that most injuries are deliberate acts performed under a false belief—most commonly, transection of the common bile duct (CBD) in the mistaken conviction that it is the cystic duct. The misperception was frequently so compelling that operative notes described the procedure as routine. This insight underpins the critical view of safety (CVS), introduced by Strasberg *et al.* (1995), which replaces an identification-by-assumption strategy with a conclusive identification test: the hepatocystic triangle is cleared of fat and fibrous tissue, the lower third of the gallbladder is separated from the cystic plate, and only two structures are seen entering the gallbladder. The multi-society practice guideline of Brunt *et al.* (2020) endorsed CVS as the method of choice for identifying the cystic structures, alongside recommendations for recognising when CVS cannot be achieved and adopting bail-out strategies such as subtotal cholecystectomy.

Rouvière's Sulcus as an Extrabiliary Landmark

CVS is a method of identification; it does not, by itself, tell the surgeon where dissection should begin or which plane is safe before the cystic structures have been exposed. Extrabiliary landmarks, which are fixed and generally unaffected by gallbladder inflammation, address this gap. Rouvière's sulcus (RS), first described by Henri Rouvière in 1924, is a 2–5 cm fissure on the inferior surface of the right hepatic lobe, running to the right of the hilum and anterior to the caudate process, and containing branches of the right portal pedicle (Dawoud *et al.*, 2024). Because the CBD lies at or below the plane of the sulcus, the guiding principle is that dissection should begin and remain ventral and cephalad to the RS plane. Nassar *et al.* (2020) formalised this as the R4U line, an imaginary line extending from RS across to the umbilical fissure (segment IV), above which dissection is considered safe.

Ezzi (2026a) evaluated the clinical utility of RS for both safety and operative efficiency in a retrospective cohort of patients undergoing LC, reinforcing its role as a reproducible orientation landmark that facilitates safe and efficient hepatocystic-triangle dissection. These findings are consistent with a growing body of evidence summarised in Table 1 and Fig. 1.

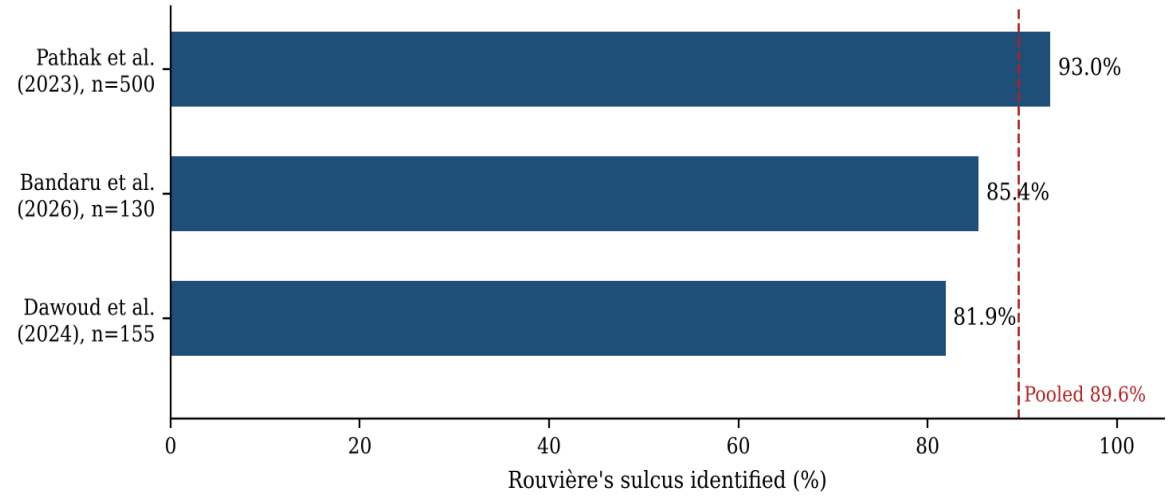


Fig. 1: Reported frequency of Rouvière's sulcus identification across three clinical cohorts. The dashed line marks the pooled estimate of 89.6% (703/785).

Two qualifications are important. First, RS is absent or obscured in roughly 7–18% of patients, depending on population and definition, and in these patients the surgeon loses an orientation aid precisely when uncertainty is highest. Second, RS should complement, not replace, CVS. Bandaru *et al.* (2026) found that RS morphology (open, slit, scar or fused) did not influence operative metrics, and explicitly cautioned that the sulcus is an adjunct to CVS and bail-out strategies. A false sulcus—a fold or scar resembling RS—has also been described, highlighting that any landmark can itself become the object of a misperception. The safest interpretation is therefore layered: RS orientates the start of dissection, CVS confirms identity before clipping, and a pre-defined bail-out pathway governs cases in which neither can be obtained.

Domain II: Vascular Anatomical Variation in the Mesenteric–Portal System

Prevalence of Variation

While biliary variants dominate the cholecystectomy literature, the mesenteric–portal venous system is at least as variable and is increasingly relevant to foregut and bariatric surgery. Two systematic reviews and meta-analyses by Negoi *et al.* (2018a, 2018b) provide the most robust pooled estimates (Table 2). The superior mesenteric vein (SMV) lacks a common trunk in 7.5% of individuals; the first jejunal vein passes posterior to the superior mesenteric artery in 71.8%; and SMV–SMA inversion occurs in 4.1%. The gastrocolic trunk of Henle, which drains into the right border of the SMV at the inferior pancreatic margin, is present in 89.7% of specimens but displays numerous tributary combinations. Even the middle colic vein, conventionally described as an SMV tributary, drains instead into the Henle trunk, inferior mesenteric vein, first jejunal trunk or splenic vein in a meaningful minority.

Variant Anatomy Encountered During Sleeve Gastrectomy

Sleeve gastrectomy is not usually regarded as an operation that places the SMV at risk, since dissection is confined to the greater curvature, the short gastric vessels and the angle of His. Nevertheless, gastrocolic and gastroepiploic venous tributaries that ultimately join the SMV through the Henle trunk lie in the operative field during greater-curvature mobilisation, particularly near the antrum. Ezzi (2026c) reported aberrant drainage of the SMV identified during sleeve gastrectomy, a rare anatomical configuration that had not been anticipated pre-operatively. Such reports, although individually anecdotal, are scientifically valuable: they demonstrate that variants catalogued mainly in pancreatic and colorectal literature can surface during routine bariatric surgery, where pre-operative cross-sectional imaging is not standard practice and surgeons may be less attuned to mesenteric venous anatomy.

The Portomesenteric Axis as a Source of Postoperative Morbidity

Knowledge of the SMV and portal axis also matters beyond the operating theatre. Portomesenteric venous thrombosis (PMVT) is a recognised, potentially lethal complication of LSG. A systematic review of 110 patients estimated the incidence of portomesenteric and splenic vein thrombosis after bariatric surgery at 0.4%; 78.9% of cases followed sleeve gastrectomy and 88.9% occurred within the first postoperative month, with morbidity and mortality of 8.2% and 3.6% (Shoar *et al.*, 2018). Shaheen *et al.* (2017) reported an incidence after LSG of 0.37–1%, and an updated meta-analysis of 101,914 sleeve gastrectomy patients estimated 0.50% (95% CI 0.40–0.61%), with advanced age and low centre volume as significant risk factors. Abdominal pain was the presenting feature in over 90% of cases, typically around three weeks post-operatively. Whether atypical venous drainage patterns contribute to regional stasis is not known, but an operative record of documented variants would provide useful context should a patient later present with mesenteric ischaemia.

Domain III: Port-Site Closure, Wound Outcomes and Trocar-Site Hernia

Skin Closure Technique and Surgical Site Infection

Port-site closure is often regarded as the most routine step of a laparoscopic operation, but it determines a significant share of patient-reported morbidity and cosmetic satisfaction. In patients with obesity, the thick subcutaneous layer, reduced tissue perfusion, and higher bacterial load create conditions

Table 2: Selected mesenteric–portal venous variations of relevance to minimally invasive abdominal surgery.

Anatomical parameter	Pooled prevalence	Source	Surgical relevance
SMV without a common trunk	7.5%	Negoi *et al.* (2018b)	Unexpected parallel venous channels at the mesenteric root
First jejunal vein posterior to SMA	71.8%	Negoi *et al.* (2018b)	Risk during infra-mesocolic or root dissection
SMV–SMA inversion	4.1%	Negoi *et al.* (2018b)	Associated with malrotation; alters expected vessel position
Henle (gastrocolic) trunk present	89.7%	Negoi *et al.* (2018a)	Source of bleeding during gastrocolic and greater-curvature dissection
Middle colic vein not draining to SMV	16.8%	Negoi *et al.* (2018a)	Drains to Henle trunk (11.7%), IMV, jejunal trunk or splenic vein
Left gastric vein draining to splenic vein	35.6%	Negoi *et al.* (2018b)	Relevant to lesser-curvature and hiatal dissection
Aberrant SMV drainage identified at LSG	Case report	Ezzi (2026c)	Documents that rare variants can surface during routine bariatric surgery

SMV, superior mesenteric vein; SMA, superior mesenteric artery; IMV, inferior mesenteric vein; LSG, laparoscopic sleeve gastrectomy. The middle colic vein figure is the complement of the 83.2% SMV-drainage rate reported by Negoi *et al.* (2018a).

Table 3: Comparative evidence on skin closure technique: staples versus subcuticular sutures.

Study	Population / design	n	Outcome (sutures vs staples)	Direction of effect
Ezzi (2026b)	LSG port sites; 4-year registry	1,655	Superficial SSI 3.54% vs 0.77%; OR for staples 0.21 (95% CI 0.09–0.48)	Favours staples
Tsujinaka *et al.* (2013)	Open GI surgery; multicentre RCT	1,072	Wound complications 8.4% vs 11.5%	No significant difference
Kobayashi *et al.* (2015)	Elective colorectal cancer surgery; RCT, 16 centres	1,264	Incisional SSI 8.7% vs 9.8% (P = .576); satisfaction 52.4% vs 42.7%	SSI equivalent; satisfaction favours sutures
Matsuno *et al.* (2021)	Open liver resection; RCT	564	Wound complications 12.5% vs 15.9% (OR 1.33; P = .241)	No significant difference overall
Goto *et al.* (2020)	Non-obstetric surgery; Cochrane review	4,163	SSI RR 0.81 (95% CI 0.64–1.01)	Little effect on SSI; fewer wound complications with sutures

LSG, laparoscopic sleeve gastrectomy; SSI, surgical site infection; GI, gastrointestinal; RCT, randomised controlled trial; OR, odds ratio; RR, risk ratio. Sample sizes refer to patients analysed.

favourable to infection and delayed healing. Ezzi (2026b) analysed 1,655 consecutive LSG cases from the Al-Emies Bariatric Center registry between January 2021 and December 2024, comparing skin staples (n = 1,034) with subcuticular sutures (n = 621). Superficial SSI was significantly more frequent with sutures (3.54% vs 0.77%; P < .001), equating to 79% lower odds of superficial infection with staples (OR 0.21; 95% CI 0.09–0.48). The suture group also required longer skin-closure time and longer time to healing. On this basis, the author concluded that skin staplers should be considered the standard approach for port-site closure in LSG.

These findings contrast in direction with much of the abdominal-surgery literature (Table 3). In open gastrointestinal surgery, the multicentre RCT of Tsujinaka *et al.* (2013) found no significant difference in wound complications between subcuticular sutures and staples (8.4% vs 11.5%), and an RCT of 1,264 colorectal cancer resections found similar 30-day incisional SSI rates (8.7% vs 9.8%; P = .576) but greater patient satisfaction with sutures (Kobayashi *et al.*, 2015). The Cochrane review of Goto *et al.* (2020) concluded with moderate certainty that subcuticular sutures probably have little effect on SSI compared with staples (RR 0.81; 95% CI 0.64–1.01; 4,163 participants) but probably reduce overall wound complications.

Several explanations may reconcile these positions. Laparoscopic port incisions are short (5–15 mm), so the time and handling advantage of staples is proportionally larger, and the potential foreign-body and tissue-handling burden of a buried suture in deep adipose tissue may be relatively greater. The extraction site in LSG is also repeatedly manipulated during specimen retrieval. Conversely, retrospective registry designs are vulnerable to confounding: a published critical appraisal of the Ezzi (2026b) study noted that the technique for obliterating subcutaneous dead space was not standardised, and that seroma or haematoma could partly account for higher suture-group complications (Gupta and Agrawal, 2026). These observations do not negate the registry's findings but do define the next research step—a pragmatic RCT in patients with obesity that standardises fascial and subcutaneous technique and reports cost, cosmesis and patient-reported outcomes.

Trocar-Site Hernia

Beyond the skin, the fascial defect is the second determinant of access-site morbidity. In a qualitative systematic review of 30,568 adults, Helgstrand *et al.* (2011) reported an overall TSH incidence of 0–5.2%; 96% of hernias occurred at trocar sites of at least 10 mm and 82% were umbilical, leading the authors to recommend fascial closure of all trocar sites of 10 mm or larger. In bariatric populations, the burden is substantially higher. A meta-analysis of 31,516 bariatric patients found a pooled incidence of 3.22% (range 0–39.3%), with higher body mass index and imaging-based surveillance independently associated with higher detection; studies specifically designed to detect TSH reported a pooled incidence of 24.5% (Karampinis *et al.*, 2019). The prospective HERBALS cohort, using systematic ultrasonography, detected TSH in 34.5% of patients and in 8.13% of all trocar sites (Karampinis *et al.*, 2020). These data indicate that TSH after bariatric surgery is under-ascertained when follow-up relies on symptomatic presentation.

DISCUSSION

An Integrated, Phase-Linked Safety Framework

The evidence reviewed here supports a central argument: safety in MIAS is a systems property distributed across the pre-operative, intra-operative and post-operative phases, rather than the product of any single technique. Each phase addresses a distinct class of hazard (Fig. 2). Anatomical variation is best addressed before and at the start of the operation, through deliberate anticipation; perceptual error is addressed during dissection through landmark-anchored orientation combined with conclusive identification; and access-site morbidity is addressed at closure and during follow-up through population-specific technique and active surveillance.

From Landmarks to a Culture of Identification

The Way *et al.* (2003) data imply that additional skill alone cannot eliminate BDI, because the dominant error is not a failure of hand but of perception. Landmarks such as RS work by providing an external reference that is independent of the structures being identified, thereby breaking the circular reasoning by which a surgeon "confirms" the identity of a duct using the same visual cues that produced the original

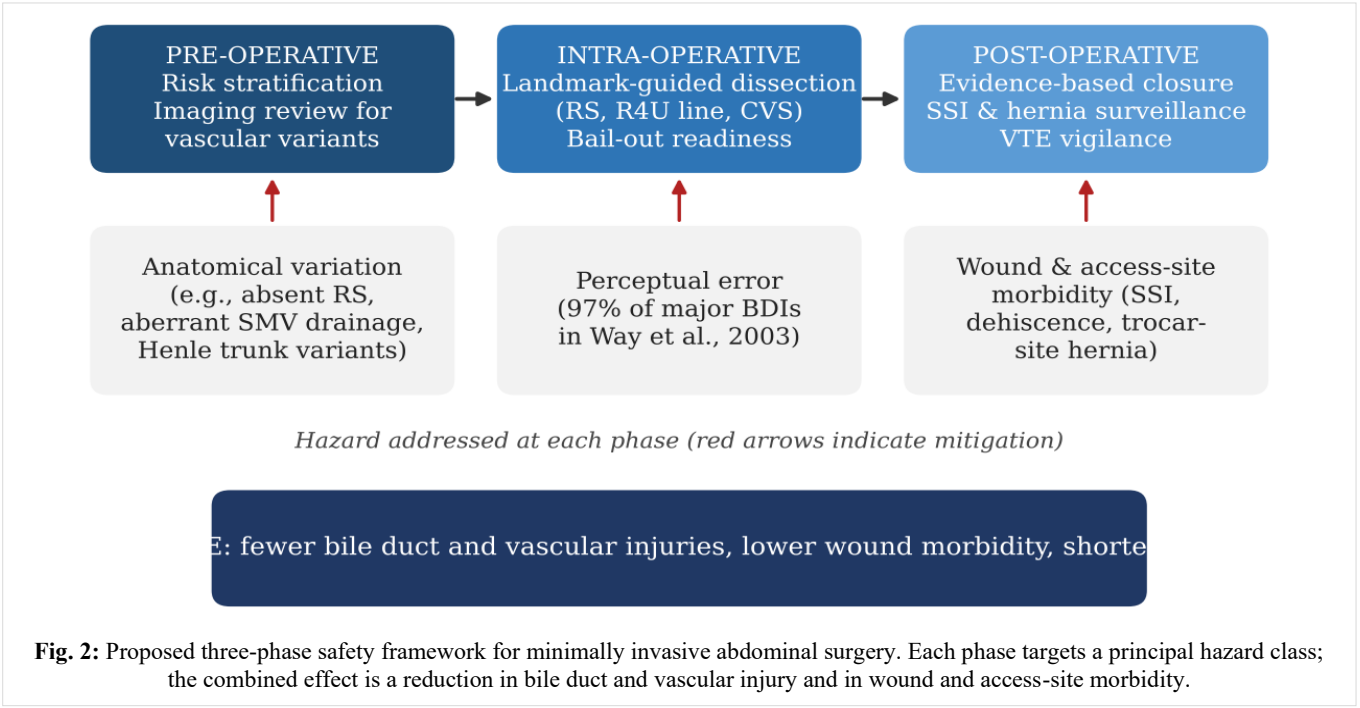


Fig. 2: Proposed three-phase safety framework for minimally invasive abdominal surgery. Each phase targets a principal hazard class; the combined effect is a reduction in bile duct and vascular injury and in wound and access-site morbidity.

misperception. The consistently high identification rates in Table 1, and the association between RS absence and longer dissection time, suggest that the sulcus is both available in most patients and informative when present. Importantly, its absence should itself be treated as a risk signal: when RS cannot be seen, the threshold for a time-out, intra-operative imaging, or a bail-out procedure should be lowered. We therefore recommend that operative notes document RS visibility and type, CVS attainment and, where applicable, the bail-out strategy adopted, so that institutional audit can relate landmark use to outcomes.

Anticipating the Unexpected: Vascular Variants in Routine Operations

Mesenteric venous variants have been studied primarily in the context of pancreaticoduodenectomy and complete mesocolic excision, where routine pre-operative computed tomography permits detailed planning. In high-volume, protocolised operations such as LSG, cross-sectional imaging is rarely performed, so variants are discovered rather than anticipated. The report of aberrant SMV drainage during sleeve gastrectomy (Ezzi, 2026c) illustrates the value of maintaining a broad anatomical awareness even in apparently standardised procedures. Practical implications include energy-device dissection that stays close to the gastric wall at the antrum, deliberate identification rather than presumption of venous tributaries before division, and a low threshold for pausing when vessel calibre or course appears atypical. Systematic recording of encountered variants in operative notes and registries would enable their true prevalence in bariatric practice to be estimated and could inform post-operative vigilance for PMVT.

Closure as a Safety Step, Not an Afterthought

The divergent findings on skin closure underline that evidence from one population cannot be transferred uncritically to another. In open abdominal surgery, sutures and staples perform similarly for SSI, with sutures offering superior satisfaction. In patients with obesity undergoing LSG, a large registry suggests a clinically relevant SSI advantage for staples. Until RCT evidence becomes available, a reasonable position is to individualise closure by population and incision type, to standardise subcutaneous dead-space management, and to audit SSI prospectively using standard definitions. At the fascial level, closure of all trocar sites of 10 mm or more is supported, and bariatric programmes should consider structured clinical or ultrasound surveillance given the high rates of occult TSH.

Strengths and Limitations

The principal strength of this review is its integration of three domains that are usually studied separately, using the highest-level evidence available for each, and its quantitative summary of landmark prevalence, venous variation and closure outcomes. Several limitations should be acknowledged. As a narrative review, it does not provide the reproducibility of a registered systematic review, and study selection may be subject to bias. The pooled RS estimate is descriptive and does not account for between-study heterogeneity in definitions, case mix or surgeon experience. Much of the evidence in Domains I and III is observational and single-centre, and case reports in Domain II cannot provide prevalence estimates. Finally, outcome definitions—particularly for SSI and TSH—vary considerably across studies, limiting direct comparison.

Priorities for Future Research

Four priorities emerge. First, prospective multicentre studies should test whether routine, documented use of RS and the R4U line, layered on CVS, reduces major BDI compared with CVS alone. Second, intra-operative imaging adjuncts such as near-infrared fluorescent cholangiography should be evaluated specifically in patients without a visible RS. Third, bariatric registries should capture encountered vascular

variants to establish their prevalence and any association with PMVT or bleeding. Fourth, a pragmatic RCT comparing staples and subcuticular sutures for port-site closure in patients with obesity, with standardised subcutaneous technique and patient-reported outcomes, is needed to confirm or refute the registry signal.

CONCLUSION

Minimally invasive abdominal surgery is safe, but its residual hazards are concentrated in predictable places: the moment of structural identification, the encounter with unanticipated anatomy, and the closure of the access wounds. Biliary injury complicates about 1 in 200 cholecystectomies yet arises overwhelmingly from misperception; Rouvière's sulcus is visible in roughly nine of every ten patients and provides a reliable external reference that complements the critical view of safety; mesenteric venous variants are common enough to warrant awareness even in standardised bariatric procedures; and closure technique measurably influences wound infection, with population-specific effects. Embedding these lessons into a phase-linked safety framework—anticipate, identify and close deliberately—offers a practical route to further reducing preventable harm in minimally invasive surgery.

Author Contributions

M.K. conceived the review and drafted the manuscript; B.W. performed the literature search and data extraction; J.H. contributed to evidence synthesis and critical revision. All authors approved the final version.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy, have been completely observed by the authors.

Life Science Reporting

Not applicable; this review analyses previously published data only.

Data Availability

All data supporting this review are available in the cited publications.

REFERENCES

1) Angrisani, L., Santonicola, A., Iovino, P., *et al.* (2021) 'Bariatric surgery survey 2018: Similarities and disparities among the 5 IFSO chapters', *Obesity Surgery*, 31(5), pp. 1937–1948. https://doi.org/10.1007/s11695-020-05207-7
2) Angrisani, L., Santonicola, A., Iovino, P., *et al.* (2024) 'IFSO worldwide survey 2020–2021: Current trends for bariatric and metabolic procedures', *Obesity Surgery, 34*(4), pp. 1075–1085. https://doi.org/10.1007/s11695-024-07118-3
3) Bandaru, S.S., Maasher, A.O., Fadlalla, Y.A., *et al.* (2026) 'Rouviere's sulcus anatomy and its overall impact on operative time and complications in laparoscopic cholecystectomy: A longitudinal observational study', *Journal of Laparoendoscopic & Advanced Surgical Techniques*, 36(6), pp. 440–444. https://doi.org/10.1177/10926429261435976
4) Brunt, L.M., Deziel, D.J., Telem, D.A., *et al.* (2020) 'Safe cholecystectomy multi-society practice guideline and state-of-the-art consensus conference on prevention of bile duct injury during cholecystectomy', *Surgical Endoscopy*, 34(7), pp. 2827–2855. https://doi.org/10.1007/s00464-020-07568-7
5) Dawoud, A.S.A., *et al.* (2024) 'Importance of Rouviere's sulcus in laparoscopic cholecystectomy', *The Egyptian Journal of Hospital Medicine*, 94(1), pp. 1104–1108. https://doi.org/10.21608/ejhm.2024.346922
6) Ezzi, M.Y. (2026a) 'The clinical utility of Rouviere's sulcus in safe and efficient laparoscopic cholecystectomy: A retrospective cohort study', *The Egyptian Journal of Surgery*, 45(2), pp. 327–332. https://doi.org/10.21608/ejsur.2025.418298.1604
7) Ezzi, M.Y. (2026b) 'Skin stapler versus subcuticular suture for port-site skin closure in patients undergoing laparoscopic sleeve gastrectomy – A registry-based retrospective study over 4 years', *Journal of Minimal Access Surgery*, preprint. https://doi.org/10.4103/jmas.jmas_136_25
8) Ezzi, M.Y. (2026c) 'Aberrant drainage of the superior mesenteric vein: A case report of a rare anatomical variation identified during sleeve gastrectomy', *World Journal of Laparoscopic Surgery*, 19(1), pp. 68–71.
9) Flum, D.R., Cheadle, A., Prela, C., *et al.* (2003) 'Bile duct injury during cholecystectomy and survival in Medicare beneficiaries', *JAMA*, 290(16), pp. 2168–2173. https://doi.org/10.1001/jama.290.16.2168
10) Goto, S., Sakamoto, T., Ganeko, R., *et al.* (2020) 'Subcuticular sutures for skin closure in non-obstetric surgery', *Cochrane Database of Systematic Reviews*, 2020(4), CD012124. https://doi.org/10.1002/14651858.CD012124.pub2
11) Gupta, N. and Agrawal, H. (2026) 'Critical appraisal of skin stapler versus subcuticular suture for port-site skin closure in laparoscopic sleeve gastrectomy', *Journal of Minimal Access Surgery*, preprint. https://doi.org/10.4103/jmas.jmas_225_26
12) Helgstrand, F., Rosenberg, J. and Bisgaard, T. (2011) 'Trocar site hernia after laparoscopic surgery: A qualitative systematic review', *Hernia*, 15(2), pp. 113–121. https://doi.org/10.1007/s10029-010-0757-x
13) Karampinis, I., Lion, E., Grilli, M., *et al.* (2019) 'Trocar site hernias in bariatric surgery—An underestimated issue: A qualitative systematic review and meta-analysis', *Obesity Surgery*, 29(3), pp. 1049–1057. https://doi.org/10.1007/s11695-018-03687-2
14) Karampinis, I., Lion, E., Hetjens, S., *et al.* (2020) 'Trocar site HERnias after Bariatric Laparoscopic Surgery (HERBALS): A prospective cohort study', *Obesity Surgery*, 30(5), pp. 1820–1826. https://doi.org/10.1007/s11695-020-04400-y
15) Kobayashi, S., Ito, M., Yamamoto, S., *et al.* (2015) 'Randomized clinical trial of skin closure by subcuticular suture or skin stapling after elective colorectal cancer surgery', *British Journal of Surgery*, 102(5), pp. 495–500. https://doi.org/10.1002/bjs.9786
16) Matsuno, Y., Yamazaki, S., Mitsuka, Y., *et al.* (2021) 'Subcuticular sutures versus staples for wound closure in open liver resection: A randomised clinical trial', *World Journal of Surgery*, 45(2), pp. 571–580. https://doi.org/10.1007/s00268-020-05833-3
17) Nassar, A.H.M., Ng, H.J. and Hamade, A.M. (2020) 'Safe cholecystectomy: The R4U line and Rouvière's sulcus', *Annals of the Royal College of Surgeons of England*, 102(2), pp. 139–142.
18) Negoi, I., Beuran, M., Hostiuc, S., *et al.* (2018a) 'Surgical anatomy of the superior mesenteric vessels related to colon and pancreatic surgery: A systematic review and meta-analysis', *Scientific Reports*, 8, 4184. https://doi.org/10.1038/s41598-018-22641-x
19) Negoi, R.I., Inoue, Y., Negoi, I., *et al.* (2018b) 'Surgical anatomy of the superior mesenteric vessels related to pancreaticoduodenectomy: A systematic review and meta-analysis', *Journal of Gastrointestinal Surgery*, 22(5), pp. 802–817. https://doi.org/10.1007/s11605-018-3669-1
20) Pathak, R., Mittal, L., Chouhan, G. M., *et al.* (2023) 'Rouviere's sulcus: A guide to safe laparoscopic cholecystectomy', *Journal of Acute Care Surgery*, 13(1), pp. 10–12. https://doi.org/10.17479/jacs.2023.13.1.10
21) Pucher, P.H., Brunt, L.M., Davies, N., *et al.* (2018) 'Outcome trends and safety measures after 30 years of laparoscopic cholecystectomy: A systematic review and pooled data analysis', *Surgical Endoscopy*, 32(5), pp. 2175–2183. https://doi.org/10.1007/s00464-017-5974-2
22) Shaheen, O., Siejka, J., Thatigotla, B., *et al.* (2017) 'A systematic review of portomesenteric vein thrombosis after sleeve gastrectomy', *Surgery*

for Obesity and Related Diseases, 13(8), pp. 1422–1431. https://doi.org/10.1016/j.soard.2017.03.015

23) Shoar, S., Saber, A.A., Rubenstein, R., *et al.* (2018) 'Portomesentric and splenic vein thrombosis (PMSVT) after bariatric surgery: A systematic review of 110 patients', *Surgery for Obesity and Related Diseases*, 14(1), pp. 47–59. https://doi.org/10.1016/j.soard.2017.09.512
24) Strasberg, S.M., Hertl, M. and Soper, N.J. (1995) 'An analysis of the problem of biliary injury during laparoscopic cholecystectomy', *Journal of the American College of Surgeons*, 180(1), pp. 101–125.
25) Tsujinaka, T., Yamamoto, K., Fujita, J., *et al.* (2013) 'Subcuticular sutures versus staples for skin closure after open gastrointestinal surgery: A phase 3, multicentre, open-label, randomised controlled trial', *The Lancet*, 382(9898), pp. 1105–1112. https://doi.org/10.1016/S0140-6736(13)61780-8
26) Way, L.W., Stewart, L., Gantert, W., *et al.* (2003) 'Causes and prevention of laparoscopic bile duct injuries: Analysis of 252 cases from a human factors and cognitive psychology perspective', *Annals of Surgery*, 237(4), pp. 460–469. https://doi.org/10.1097/01.SLA.0000060680.92690.E9