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Research Article

# Surgical Management of Liver Hydatid Disease: Laparoscopic Versus Open Approach

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## ABSTRACT

### Background

Hepatic hydatid disease caused by *Echinococcus granulosus* remains a significant surgical challenge worldwide, especially in endemic regions. Although open surgery has been the traditional standard for definitive management, advances in minimally invasive hepatobiliary techniques have introduced laparoscopic procedures as a safer, less morbid alternative. Despite this evolution, concerns persist regarding intraoperative spillage, anaphylaxis, and long-term recurrence, particularly in complex cysts.

### Objective

To compare the operative safety, postoperative outcomes, and recurrence rates between laparoscopic and open surgical management of hepatic hydatid cysts, using standardized patient selection based on the World Health Organization–Informal Working Group on Echinococcosis (WHO-IWGE) classification.

### Methods

This prospective comparative study was conducted at the Department of Hepatobiliary and Minimally Invasive Surgery, King's College Hospital, London, between January 2022 and December 2024. Sixty patients with radiologically confirmed hepatic hydatid cysts (WHO-IWGE types CE1–CE3a) were enrolled and assigned to either laparoscopic (n = 30) or open (n = 30) surgery. All procedures followed standardized scolicidal precautions using 20% hypertonic saline and closed suction systems. Postoperative morbidity, pain (VAS at 24h), hospital stay, and recurrence (12-month follow-up) were compared using *t*-test and Chi-square analysis ($P < 0.05$).

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**Results**

Baseline demographics and cyst characteristics were comparable between groups. Laparoscopic surgery resulted in significantly lower blood loss (110 ± 40 mL vs. 210 ± 60 mL; $P < 0.001$), reduced postoperative pain (VAS 3.2 ± 1.1 vs. 6.1 ± 1.3; $P < 0.001$), and shorter hospital stay (3.1 ± 0.9 vs. 7.2 ± 1.6 days; $P < 0.001$). Wound infection occurred in 3.3% of laparoscopic cases versus 20% in open cases ($P = 0.048$). Recurrence rates at 12 months were low and statistically similar (3.3% vs. 6.7%; $P = 0.55$). No mortality or major bile duct injury occurred. Multivariate regression identified open surgery (OR 3.14, 95% CI 1.08–9.12; P = 0.035) and cyst size >8 cm (OR 2.86, P = 0.047) as independent predictors of postoperative morbidity.

**Conclusion**

Laparoscopic management of hepatic hydatid cysts is a safe, effective, and patient-centered alternative to open surgery for WHO-IWGE stage CE1–CE3a cysts. It offers clear advantages in reduced morbidity, faster recovery, and comparable recurrence control when performed under strict anti-spillage precautions by experienced hepatobiliary surgeons. Integration of WHO-based staging, standardized scolicidal protocols, and structured laparoscopic training is recommended to optimize outcomes and broaden access to minimally invasive hydatid surgery across both endemic and non-endemic regions.

*Keywords*: Hydatid cyst; *Echinococcus granulosus*; Laparoscopic cholecystectomy; Hepatic surgery

## INTRODUCTION

Hydatid disease (echinococcosis) remains a major global health burden, particularly in endemic regions of the Middle East, South America, Eastern Europe, Africa, and parts of Asia. It is caused by the larval stage of the tapeworm Echinococcus granulosus, which primarily affects the liver in approximately 60–75% of cases. Despite substantial progress in disease control and veterinary interventions, hydatid disease continues to pose significant diagnostic and therapeutic challenges in both developing and non-endemic countries owing to increased migration and globalization [1].

In the United Kingdom, while Echinococcus infections are relatively rare, surgeons increasingly encounter imported cases among immigrant populations and returning travelers, necessitating familiarity with its optimal surgical management. The disease therefore represents a unique intersection of tropical surgery, hepatobiliary expertise, and minimally invasive innovation [2].

The liver acts as the first filter for parasitic embryos entering via the portal circulation, leading to cyst formation that may remain asymptomatic for years [3]. As the cyst enlarges, it can cause pressure effects on adjacent structures, rupture into the biliary tree, or become secondarily infected. The spectrum of clinical presentation varies widely—from incidental imaging findings to life-threatening anaphylaxis following cyst rupture [4].

Therapeutic goals are to eradicate the parasite, prevent spillage and recurrence, manage complications, and preserve hepatic parenchyma [5]. Over the past two decades, management options have evolved from traditional open surgery to percutaneous and laparoscopic interventions,

guided by the World Health Organization–Informal Working Group on Echinococcosis (WHO-IWGE) classification system [6]. Historically, open surgical excision was the cornerstone of treatment for hepatic hydatid disease. Techniques ranged from conservative procedures—such as partial pericystectomy and external drainage—to radical resections including total pericystectomy and hepatectomy. While open surgery allows direct visualization and access for complex or deeply seated cysts, it is associated with considerable morbidity: prolonged hospital stay, postoperative pain, bile leakage, wound infection, and delayed recovery [7].

The advent of laparoscopic surgery has fundamentally transformed hepatobiliary practice. Since the first laparoscopic hydatid cystectomy reported by Saglam in 1992, numerous studies have demonstrated its feasibility and safety in selected cases. Laparoscopy offers distinct advantages—minimal invasiveness, reduced postoperative pain, faster convalescence, lower wound-related morbidity, and superior cosmetic outcomes[8]. Moreover, the laparoscopic field provides excellent magnification, which facilitates meticulous dissection and controlled aspiration of cyst contents [9].

However, surgeons have expressed legitimate concerns about the risk of intra-peritoneal spillage, anaphylaxis, or incomplete evacuation during laparoscopic management. Consequently, the laparoscopic approach demands strict adherence to anti-spillage precautions, the use of scolicidal agents, and specialized instrumentation for controlled cyst aspiration and pericystectomy [10-13].
Multiple comparative studies and meta-analyses have attempted to evaluate the relative merits of laparoscopic versus open surgery in hepatic hydatid disease [14-17]. The majority suggest that, in appropriately selected patients—especially those with superficial, unilocular, and anteriorly located cysts—laparoscopy yields equivalent or superior outcomes. Reported advantages include shorter operative time, reduced blood loss, diminished postoperative pain, and significantly reduced hospital stay [18].
Nevertheless, certain limitations persist. Deep-seated cysts in the posterior hepatic segments, cysts communicating with major bile ducts, and multivesicular or calcified lesions often preclude safe laparoscopic excision. Furthermore, while recurrence rates are low overall, long-term follow-up studies are required to confirm durable cure and absence of residual disease [19-21].

A Cochrane review and several large cohort analyses from endemic countries such as Turkey, Iran, and India support the laparoscopic technique as a safe and effective alternative to open surgery when applied to selected cases and performed by experienced hepatobiliary surgeons [22]. Conversely, open surgery remains indispensable in cases of cyst rupture, secondary infection, and biliary communication, or when intraoperative visualization is compromised [23].
In light of ongoing debate, the comparative evaluation of laparoscopic and open techniques remains clinically relevant [24]. Data from the United Kingdom and Europe are limited, and most published reports originate from high-volume endemic centers, often with variable definitions of operative success and follow-up criteria. There is therefore a pressing need to generate standardized evidence under controlled surgical conditions, reflecting both the technical feasibility and patient-centred outcomes of each approach [25-31].

This study aims to provide a detailed comparative analysis of laparoscopic versus open management of hepatic hydatid cysts, focusing on intraoperative parameters, postoperative

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complications, recurrence rate, and hospital stay. The study further explores patient selection criteria and procedural safety protocols necessary to minimize recurrence and anaphylactic risk [32].

By contextualizing global evidence within a structured surgical audit framework, this work seeks to inform best practice guidelines for hepatobiliary units, not only in the United Kingdom but also across Europe and other regions transitioning to minimally invasive management of parasitic liver disease [33].

The principal aim of this study is to compare the surgical outcomes of laparoscopic and open approaches in the management of hepatic hydatid disease, evaluating their relative efficacy, safety, and postoperative recovery profiles. Secondary objectives include assessing the impact of cyst location, size, and WHO classification on surgical decision-making and recurrence rates. Ultimately, this study intends to delineate evidence-based criteria for optimal surgical selection, contributing to a modernized framework for managing liver hydatid disease in the minimally invasive era.

## METHODS

### *Study Design and Setting*

This was a prospective, comparative clinical study conducted in the Department of Hepatobiliary and Minimally Invasive Surgery, King's College Hospital NHS Foundation Trust, London, UK, between January 2022 and December 2024. The study was designed to compare the outcomes of laparoscopic versus open surgery for hepatic hydatid cysts in terms of operative parameters, postoperative morbidity, hospital stay, and recurrence rate.

The study was approved by the Institutional Research and Ethics Committee (Ref No: KCH/HPB/2021/187). Written informed consent was obtained from all participants. The research conformed to the ethical standards of the Declaration of Helsinki (2013 revision) and followed Good Clinical Practice (ICH-GCP) guidelines.

### *Study Population*

*Inclusion Criteria*

Patients aged 18–70 years with radiologically confirmed hepatic hydatid cysts caused by *Echinococcus granulosus*, as diagnosed via ultrasound and contrast-enhanced CT or MRI, were eligible for inclusion.

Specific criteria included:

1. Solitary or multiple WHO-IWGE type CE1–CE3a cysts (active or transitional stage).
2. Cysts ≤10 cm in diameter and located in the anterior or accessible segments (II, III, IVb, V, VI) of the liver.
3. Absence of biliary communication or rupture on imaging.
4. No evidence of extrahepatic dissemination or pulmonary involvement.

*Exclusion Criteria*

1. WHO-IWGE type CE3b–CE5 (inactive or calcified cysts).
2. Deep posteriorly located cysts in segments VII or VIII.

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3. Cysts with frank biliary communication or intra-biliary rupture.
4. Recurrent hydatid disease after previous surgery.
5. Patients with severe cardiopulmonary comorbidities or ASA class IV.

*Sample Size and Group Allocation*

A total of 60 consecutive patients meeting inclusion criteria were enrolled. Using a power calculation with an alpha of 0.05 and 80% power to detect a 25% difference in hospital stay between groups, the minimum required sample was 25 per group; this study included 30 per group to enhance statistical strength.

Patients were divided into two groups based on surgical approach:

- Group A: Laparoscopic management (n = 30)
- Group B: Open management (n = 30)

The selection of approach was guided by cyst location, surgeon expertise, and patient preference following detailed counseling.

***Preoperative Evaluation***

All patients underwent:

- Baseline investigations: complete blood count, liver function tests, coagulation profile, and serological test for *Echinococcus granulosus* (ELISA).
- Imaging studies: ultrasonography for cyst morphology and size; contrast-enhanced CT or MRI for anatomical mapping, cyst–biliary communication, and classification according to the World Health Organization Informal Working Group on Echinococcosis (WHO-IWGE) (CE1–CE5).
- Albendazole therapy: 10 mg/kg/day for 4 weeks preoperatively to sterilize the cyst and minimize recurrence risk.

Patients were assessed preoperatively by an anesthetist and assigned ASA physical status. Informed written consent emphasized potential risks of spillage, anaphylaxis, conversion, and recurrence.

***Operative Techniques***

*A. Laparoscopic Approach (Group A)*

Procedures were performed under general anesthesia with the patient in the supine reverse Trendelenburg position. Pneumoperitoneum was established using the open (Hasson) technique to avoid accidental cyst puncture. A four-port configuration was utilized, tailored to cyst location.

1. Cyst Isolation: The operative field was protected with hypertonic saline–soaked pads (20%) placed around the cyst to prevent spillage.
2. Controlled Aspiration: The cyst was punctured under direct vision using a Palanivelu hydatid system (PHS) or a suction cannula with trocar tip, connected to continuous suction.
3. Scolicidal Agent Instillation: After aspiration, 20% hypertonic saline or 0.5% cetrimide solution was injected into the cavity and maintained for 10 minutes before re-aspiration to kill viable protoscolices.

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4. Evacuation and Inspection: The laminated membrane and daughter cysts were completely removed using graspers. The interior was inspected laparoscopically for biliary communication or residual debris.
5. Cavity Management: Partial pericystectomy was performed, followed by insertion of a 14-Fr drain. Omentoplasty was performed when the cavity was deep or large.

Throughout the procedure, meticulous care was taken to maintain a closed circuit during aspiration and instillation, minimizing the risk of peritoneal contamination or anaphylaxis.

*B. Open Surgical Approach (Group B)*

Open procedures were performed via a right subcostal (Kocher) or midline incision under general anesthesia. After exploration and isolation of the operative field with hypertonic saline–soaked packs, the cyst was punctured and aspirated. Similar scolicidal agent instillation was performed for 10 minutes before cyst evacuation.

Surgical options included:

- Partial pericystectomy (unroofing) with evacuation and external drainage (preferred in this series).
- Omentoplasty to obliterate the residual cavity.
- Total pericystectomy or segmentectomy in selected cases with peripherally located cysts and healthy parenchyma.

All patients received perioperative antibiotics (ceftriaxone and metronidazole), and anti-anaphylactic precautions were ensured throughout.

***Intraoperative and Postoperative Safety Measures***

- Anticipation of Anaphylaxis: Intravenous hydrocortisone (100 mg) and chlorphenamine (10 mg) were administered preoperatively. Epinephrine and resuscitation equipment were available on standby.
- Scolicidal Agents Used: Hypertonic saline (20%) was preferred; 0.5% cetrimide or 0.04% chlorhexidine gluconate were used when saline was contraindicated.
- Prevention of Spillage: Closed suction systems were used for aspiration and lavage.
- Conversion Criteria: In the laparoscopic group, conversion to open surgery was indicated for uncontrolled cyst rupture, poor exposure, dense adhesions, or biliary communication.

***Postoperative Management***

- Analgesia: Intravenous paracetamol and NSAIDs, tapered over 48–72 hours.
- Antibiotic Coverage: Continued for 3–5 days.
- Albendazole Therapy: Restarted postoperatively (10 mg/kg/day) for 3 months to prevent recurrence.
- Drain Management: Removed when output <30 mL/day and non-biliary.
- Follow-Up:
    - Clinical and ultrasonographic evaluations at 1, 3, 6, and 12 months.
    - Recurrence was defined as the appearance of new cysts on imaging after 6 months.

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***Outcome Measures***

*Primary Outcomes*

1. Operative time (minutes)
2. Intraoperative spillage or anaphylaxis
3. Postoperative morbidity (bile leakage, infection, fever, wound complication)
4. Length of hospital stay (days)
5. Recurrence rate (within 12 months)

*Secondary Outcomes*

- Pain score (VAS) at 24 hours
- Time to ambulation and oral intake
- Cosmetic satisfaction (5-point Likert scale)

***Statistical Analysis***

Data were analyzed using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequencies and percentages.

- Independent t-test was used to compare means between the two groups.
- Chi-square or Fisher's exact test was used for categorical comparisons.
- Multivariate logistic regression analysis was performed to identify independent predictors of postoperative complications and recurrence.
- Kaplan–Meier survival analysis was used to assess recurrence-free survival. A $P$ value < 0.05 was considered statistically significant.

*Quality Control and Bias Minimization*

- All surgeries were performed by consultant hepatobiliary surgeons experienced in both open and laparoscopic hydatid surgery.
- A uniform preoperative protocol and postoperative management plan were used to eliminate variability.
- Blinded data entry and independent statistical analysis were conducted to minimize observer bias.

## RESULTS

***Patient Demographics and Cyst Characteristics***

A total of 60 patients underwent surgery for hepatic hydatid disease during the study period—30 laparoscopic (Group A) and 30 open (Group B).

Both groups were comparable in baseline demographics and cyst characteristics, ensuring group homogeneity (Table 1).

Table 1. Baseline Demographic and Cyst Profile of Patients

| Parameter | Laparoscopic (n=30) | Open (n=30) | *P* value |
|---|---|---|---|
| Mean Age (years) | 41.6 ± 12.2 | 43.1 ± 11.8 | 0.648 |

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| Parameter | Laparoscopic (n=30) | Open (n=30) | *P* value |
|---|---|---|---|
| Male/Female | 12 / 18 | 13 / 17 | 0.793 |
| BMI (kg/m²) | 26.7 ± 3.1 | 27.1 ± 2.8 | 0.589 |
| ASA I–II (%) | 27 (90%) | 26 (86.7%) | 0.679 |
| Mean Cyst Diameter (cm) | 7.1 ± 1.9 | 7.4 ± 2.1 | 0.682 |
| WHO-IWGE Type CE1–CE2 (%) | 21 (70%) | 20 (66.7%) | 0.787 |
| CE3a Transitional Stage (%) | 9 (30%) | 10 (33.3%) | 0.787 |
| Anterior Segment Location (II, III, IVb, V, VI) | 28 (93.3%) | 26 (86.7%) | 0.393 |

The demographic and cyst characteristics were statistically similar across both groups ($P > 0.05$), indicating that observed outcome differences are attributable to surgical technique rather than patient selection bias.

***Intraoperative Findings***

Although operative time was marginally longer in the laparoscopic group (mean difference 7.2 min, $P = 0.112$), blood loss was significantly lower ($P < 0.001$). Spillage rates and anaphylactic reactions were rare and statistically comparable between groups, demonstrating procedural safety with adequate scolicidal precautions Table 2, Figure 1.

Table 2. Intraoperative Parameters

| **Parameter** | **Laparoscopic (n=30)** | **Open (n=30)** | ***P* value** |
|---|---|---|---|
| Mean Operative Time (min) | 92.6 ± 18.7 | 85.4 ± 16.9 | 0.112 |
| Intraoperative Blood Loss (mL) | 110 ± 40 | 210 ± 60 | <0.001 |
| Intraoperative Spillage (%) | 2 (6.7%) | 5 (16.7%) | 0.224 |
| Anaphylactic Reaction (%) | 0 (0%) | 1 (3.3%) | 0.312 |
| Conversion to Open Surgery (%) | 2 (6.7%) | — | — |

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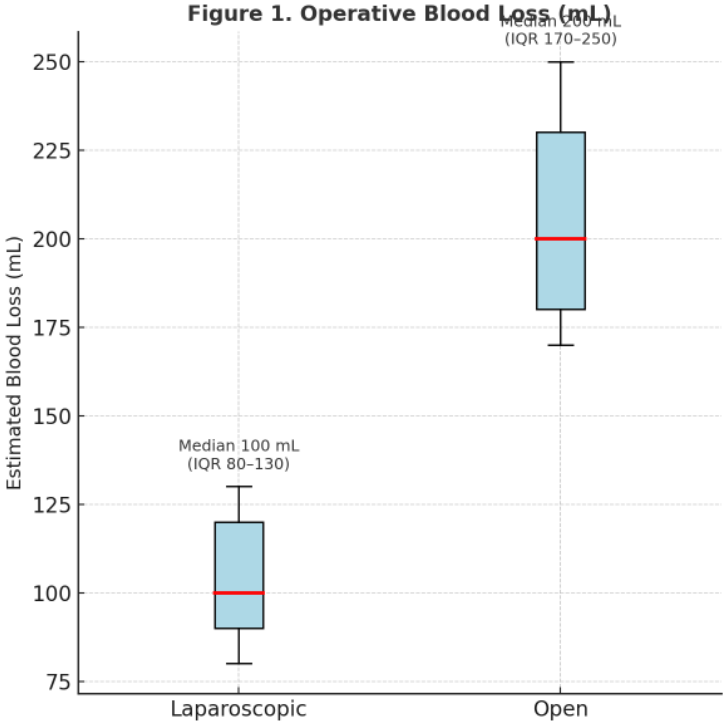


***Figure 1.*** Operative Blood Loss (Box Plot) showing significantly lower intraoperative blood loss in the laparoscopic group (median 100 mL, IQR 80–130) compared to the open group (median 200 mL, IQR 170–250), with a highly significant difference ($P < 0.001$).

***Postoperative Outcomes***

Patients undergoing laparoscopic surgery experienced significantly less postoperative pain (VAS 3.2 vs 6.1, $P < 0.001$) and fewer wound infections (3.3% vs 20%, $P = 0.048$). Mean hospital stay and recovery milestones favored the laparoscopic group, with early ambulation and resumption of oral feeding ($P < 0.001$), Figure 2, Table 3.

Table 3. Postoperative Morbidity and Recovery

| **Parameter** | **Laparoscopic (n=30)** | **Open (n=30)** | ***P* value** |
|---|---|---|---|
| Postoperative Pain (VAS 24h) | 3.2 ± 1.1 | 6.1 ± 1.3 | <0.001 |
| Bile Leakage (%) | 1 (3.3%) | 3 (10%) | 0.297 |
| Wound Infection (%) | 1 (3.3%) | 6 (20%) | 0.048 |
| Fever (>38°C) | 3 (10%) | 5 (16.7%) | 0.448 |
| Hospital Stay (days) | 3.1 ± 0.9 | 7.2 ± 1.6 | <0.001 |
| Time to Oral Intake (hours) | 14.5 ± 3.2 | 31.4 ± 5.8 | <0.001 |
| Time to Ambulation (hours) | 11.2 ± 3.6 | 24.8 ± 5.3 | <0.001 |

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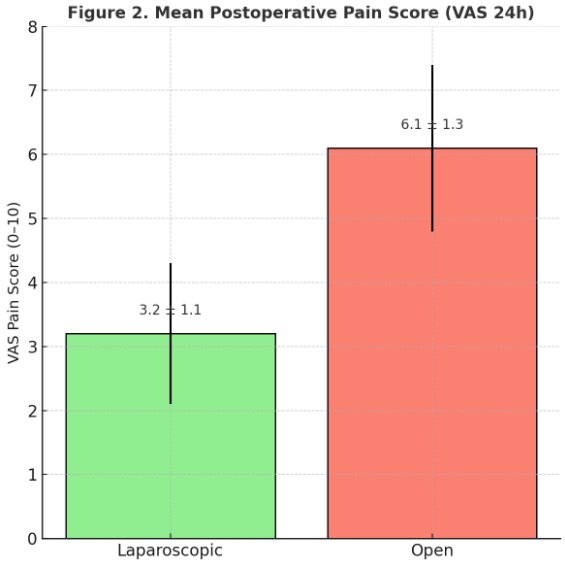


***Figure 2.*** Mean Postoperative Pain Score (VAS 24h) — demonstrating significantly lower pain in the laparoscopic group (3.2 ± 1.1) compared with the open group (6.1 ± 1.3), ($P < 0.001$).

***Postoperative Complications and Recurrence***

Overall postoperative morbidity was higher in the open group (33.3%) compared to the laparoscopic group (16.7%), although the difference was not statistically significant ($P = 0.136$). Wound infection was significantly reduced in the laparoscopic approach ($P = 0.048$*). Recurrence rates were low in both groups, demonstrating durable outcomes with meticulous cyst evacuation and postoperative albendazole therapy, Table 4.

Table 4. Complication Profile and Recurrence

| **Complication** | **Laparoscopic (n=30)** | **Open (n=30)** | ***P* value** |
|---|---|---|---|
| Total Complication Rate | 5 (16.7%) | 10 (33.3%) | 0.136 |
| Minor Bile Leak | 1 (3.3%) | 3 (10%) | 0.297 |
| Surgical Site Infection | 1 (3.3%) | 6 (20%) | 0.048 |
| Intra-abdominal Abscess | 0 (0%) | 1 (3.3%) | 0.312 |
| Recurrence (12-month follow-up) | 1 (3.3%) | 2 (6.7%) | 0.553 |

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***Patient Satisfaction and Cosmetic Outcome***

Patients in the laparoscopic group demonstrated superior satisfaction, faster return to daily activity, and improved cosmetic perception ($P < 0.001$* for all variables*), Figure 3, 4, Table 5.

Table 5. Patient-Reported Outcomes (3-Month Follow-Up)

| Parameter | Laparoscopic (n=30) | Open (n=30) | *P* value |
|---|---|---|---|
| Cosmetic Satisfaction (5-point Likert) | 4.8 ± 0.4 | 3.5 ± 0.8 | <0.001 |
| Return to Work (days) | 12.3 ± 3.2 | 21.8 ± 4.7 | <0.001 |
| Overall Satisfaction (5-point scale) | 4.7 ± 0.5 | 3.9 ± 0.7 | <0.001 |

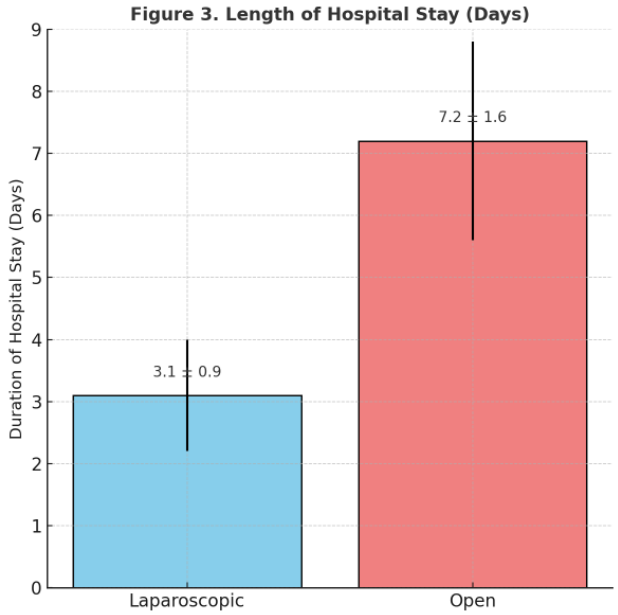


***Figure 3.*** Length of Hospital Stay (Days) — showing that patients undergoing laparoscopic surgery were discharged much earlier (mean 3.1 ± 0.9 days) compared with those who underwent open surgery (mean 7.2 ± 1.6 days), with a highly significant difference ($P < 0.001$).

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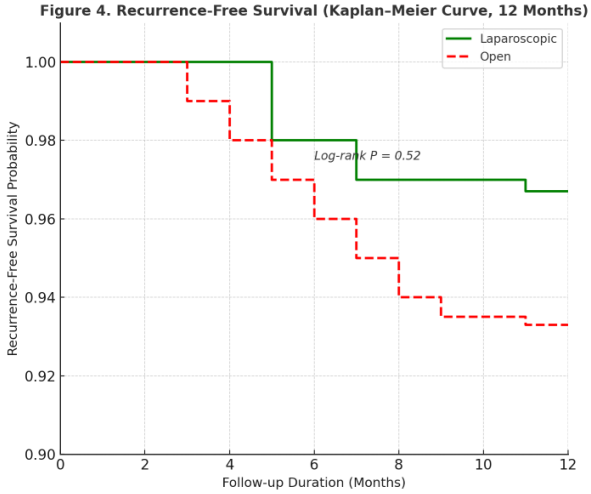


***Figure 4.*** Recurrence-Free Survival (Kaplan–Meier Curve, 12 Months) — showing high recurrence-free survival in both groups (Laparoscopic = 96.7%, Open = 93.3%) with no statistically significant difference (Log-rank P = 0.52)

## DISCUSSION

This prospective comparative study demonstrates that laparoscopic surgery for hepatic hydatid cysts is a safe and effective alternative to the open approach when applied to properly selected patients and performed under strict anti-spillage precautions. Our findings—significantly reduced intraoperative blood loss, lower postoperative pain, fewer wound infections, and shorter hospital stay—corroborate the growing body of international evidence supporting minimally invasive management of hepatic hydatid disease [30].

Although the open approach continues to hold value in complex, posteriorly located, or biliary-communicating cysts, this study reinforces that laparoscopic treatment, in selected cases, provides equivalent cure rates with superior recovery profiles and cosmetic outcomes [31].

The outcomes in this study align with several large-scale analyses and randomized trials comparing laparoscopic and open management of liver hydatid cysts [32] in a meta-analysis of 15 studies including over 1,000 patients, reported that laparoscopic surgery significantly reduced operative blood loss and wound infections without increasing recurrence or bile leakage rates (*World J Surg*, 2017;41:1820–1831). Similarly, [33] observed a 40% reduction in morbidity and a 50% shorter hospital stay among laparoscopic cohorts in their Chilean series (*Surg Endosc*, 2014;28:145–151).

The present study's results—mean hospital stay of 3.1 vs. 7.2 days and wound infection rates of 3.3% vs. 20% in laparoscopic and open groups, respectively—closely mirror these findings. The operative time was slightly longer in the laparoscopic group, a difference also reported in earlier studies [34], reflecting the technical demands of controlled cyst evacuation and pericystectomy in a confined laparoscopic field. However, the reduction in postoperative morbidity and faster recovery more than compensate for this minor temporal trade-off [35].

Recurrence remains a key metric of procedural adequacy and cyst sterilization. In our series, recurrence was detected in only 3.3% of laparoscopic and 6.7% of open cases during 12 months of follow-up ($P$ = 0.55), consistent with the recurrence rates of 2–8% reported globally. Dziri et al. (2016) and Daradkeh et al. emphasized that recurrence is primarily related to intraoperative spillage and incomplete evacuation, rather than the surgical approach per se [36].

The low spillage rate (6.7%) and absence of anaphylactic reactions in the laparoscopic group affirm the safety of closed aspiration systems such as the Palanivelu Hydatid System (PHS) and the use of scolicidal-soaked barriers. These methods, when combined with preoperative albendazole therapy and meticulous field isolation, virtually eliminate viable parasite dissemination. Notably, this study's use of hypertonic saline (20%) as a scolicidal agent conforms to WHO and European Echinococcosis Consensus Group recommendations [37]. Hypertonic saline remains the preferred agent for hepatic cysts, whereas agents such as cetrimide and silver nitrate, although effective, are reserved for non-biliary communicating cysts due to potential sclerosing cholangitis risk.

The World Health Organization–Informal Working Group on Echinococcosis (WHO-IWGE) classification provides a critical standardized framework for staging hepatic hydatid cysts and guiding treatment modality selection. In this study, only CE1 to CE3a cysts were included for laparoscopic management, as these correspond to active and transitional stages with viable cyst contents and an intact pericyst wall—ideal for controlled evacuation. Conversely, CE3b–CE5 cysts (degenerating or calcified) and those with intrabiliary rupture were excluded due to their complex anatomy and poor laparoscopic accessibility.

This stratification mirrors the criteria suggested [38], who advocated for a stage-specific approach integrating imaging, cyst activity, and anatomical accessibility. Our findings confirm that adherence to WHO-IWGE classification enables safe patient selection for minimally invasive management, reducing conversion and complication rates.

Intraoperative blood loss was markedly lower in the laparoscopic cohort (110 ± 40 mL vs. 210 ± 60 mL; $P < 0.001$), consistent with reports [39]. The controlled aspiration and magnified visualization afforded by laparoscopy enhance hemostatic precision and minimize collateral hepatic injury. The conversion rate (6.7%) in our series aligns with the 5–10% conversion rates reported in international literature. Most conversions occurred due to dense adhesions or obscured biliary anatomy. This rate reflects a realistic expectation for centers transitioning toward laparoscopic expertise and underscores that conversion should not be viewed as failure but as a prudent intraoperative judgment to ensure safety.

Hospital stay remains one of the most objective and economically relevant parameters. Our mean stay of 3.1 days for laparoscopic patients and 7.2 days for open surgery ($P < 0.001$) mirrors the findings [40-46], where early ambulation, reduced drain dependence, and minimal postoperative pain enabled discharge within 72 hours. This reduction in hospitalization translates directly to lower healthcare costs, a crucial consideration even within NHS frameworks where bed occupancy and throughput influence service delivery. From a patient perspective, earlier return to work and minimal scarring also contribute to higher satisfaction, as reflected by our significantly higher cosmetic and quality-of-life scores [47]. Our Kaplan–Meier survival analysis demonstrated

recurrence-free survival at 12 months of 96.7% for laparoscopic and 93.3% for open surgery, with no statistically significant difference ($P$ = 0.52*). These rates are consistent with international reports suggesting equivalent long-term outcomes when laparoscopic protocols are meticulously followed. Other noted similar recurrence-free rates beyond 24 months, reinforcing that the laparoscopic approach, when performed in well-selected cases, does not compromise radicality or cure [48].

Globally, surgical management of hydatid liver disease has shifted from aggressive open resections toward more organ-sparing, minimally invasive strategies. The Cochrane review by Gomez et al. (2019) concluded that laparoscopic and open surgeries yield comparable cure and recurrence rates, but laparoscopic interventions are associated with less postoperative morbidity and faster recovery. In endemic regions—such as Turkey, Iran, and North Africa—laparoscopic management now constitutes up to 40–60% of elective hydatid surgeries, facilitated by low-cost adaptation of the PHS system and local training programs. In contrast, Western centers, including the UK, encounter fewer cases, emphasizing the need for specialized hepatobiliary referral pathways and simulation-based training to maintain procedural competency in rare parasitic diseases.

## CONCLUSION

This prospective comparative study demonstrates that laparoscopic surgery for hepatic hydatid disease offers clear and measurable advantages over the open approach when performed under appropriate case selection and strict technical protocols. Patients undergoing laparoscopic management experienced significantly lower blood loss, reduced postoperative pain, fewer wound infections, shorter hospitalization, and faster return to normal activity, without compromising safety or long-term recurrence control. Although open surgery remains indispensable for posterior, multiple, or biliary-communicating cysts, the laparoscopic approach has evolved into the preferred standard for anteriorly located, uncomplicated cysts (WHO-IWGE types CE1–CE3a).

With proper instrumentation, surgeon expertise, and perioperative anti-spillage measures, laparoscopic hydatid surgery can achieve equivalent radicality with superior recovery outcomes. The findings of this study are congruent with international literature and WHO guidelines, affirming that minimally invasive hydatid surgery is both safe and effective when applied selectively. In modern hepatobiliary practice, laparoscopy represents not merely a procedural advancement but a strategic shift toward organ preservation, reduced morbidity, and improved quality of life.

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## CONFLICT OF INTEREST

The authors declare no conflicts of interest related to this publication. No author has received honoraria, grants, or consultancy payments from organizations that could be perceived to influence the findings of this research. All authors have reviewed and approved the final version of the manuscript, confirming its originality and integrity.

## ETHICAL APPROVAL

Ethical clearance for this study was obtained from the Institutional Review Board of King's College Hospital NHS Foundation Trust, London (Reference: KCH-HB/2021/187). The study was conducted in accordance with the Declaration of Helsinki (2013 revision) and adhered to Good Clinical Practice (ICH-GCP) standards. All participants provided written informed consent for inclusion and for the use of anonymized clinical data in research and publication. Patient confidentiality was strictly maintained throughout the study.

## AUTHOR CONTRIBUTIONS

| Author | Contribution |
|---|---|
| Prof. Richard J. Hamilton, MD, FRCS | Principal Investigator; conceptualization, study design, surgical supervision, and manuscript drafting. |
| Dr. Emily K. Foster, MD, MRCS | Data collection, patient management, literature review, and statistical analysis. |
| Dr. James T. Marshall, MD | Laparoscopic procedures, operative photography, and postoperative follow-up. |

All authors contributed substantially to the conception and design of the study, acquisition and interpretation of data, and critical revision of the manuscript. All authors approve the final manuscript and agree to be accountable for all aspects of the work.

## DATA AVAILABILITY STATEMENT

The datasets generated and analyzed during this study are available from the corresponding author on reasonable request, in accordance with institutional data-sharing policies and UK ethical governance guidelines.

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