Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Short-Term Outcomes of Robotic, Laparoscopic, and Open Inguinal Hernia Repair: A Single-Centre Cohort Study

Stuart A. Cowie

stuart.cowie@nhs.net

Northumbria Healthcare NHS Foundation Trust

Olivia Kent

Northumbria Healthcare NHS Foundation Trust

Robyn Bartlett

Northumbria Healthcare NHS Foundation Trust

Edward J. Nevins

Northumbria Healthcare NHS Foundation Trust

Liam F. Horgan

Northumbria Healthcare NHS Foundation Trust

Research Article

Keywords:

Posted Date: November 23rd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11340845/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Short-Term Outcomes of Robotic, Laparoscopic, and Open Inguinal Hernia Repair: A Single-Centre Cohort Study

Authors: Stuart A. Cowie, Olivia Kent, Robyn Bartlett, Edward J Nevins, Liam F. Horgan

Corresponding Author: Stuart A. Cowie, Department of General Surgery, Northumbria Healthcare NHS Foundation Trust, North Shields, UK. Email: stuart.cowie@nhs.net

Abstract

*Background***:** Robotic-assisted surgery is gaining traction within benign general surgical practice in the UK, with robotic inguinal hernia repair (RIHR) now among the most frequently performed procedures. Despite this, evidence comparing RIHR against established laparoscopic (LIHR) and open (OIHR) techniques remains limited, particularly in a UK setting.

*Methods***:** We carried out a retrospective cohort study of elective inguinal hernia repairs undertaken at a single NHS trust. Patients were stratified by operative technique: RIHR (n=100), LIHR (n=100), and OIHR (n=100). Variables included patient demographics, operative time, intra-operative complications, rates of same-day discharge, and 30-day outcomes. Continuous variables were tested with one-way ANOVA, and categorical variables with chi-squared or Fisher's exact tests.

*Results***:** Open repair was associated with higher ASA classification reflecting its use in older, more co-morbid patients. Bilateral repairs were more often performed with minimally invasive techniques. Operative times differed significantly with LIHR shortest, OIHR longest, and RIHR intermediate but reduced over time, consistent with a learning curve effect. Same-day discharge exceeded 90% in the minimally invasive groups. Thirty-day outcomes were comparable across modalities. No conversions or emergency undockings occurred within the robotic cohort.

*Conclusion***:** RIHR is a safe and feasible alternative to conventional laparoscopic and open approaches within a day-case setting. Short-term outcomes were comparable to LIHR and favourable to OIHR, and operative efficiency improved with experience. These findings support the wider adoption of RIHR in hernia practice, while highlighting the need for prospective, multi-centre data and cost-effectiveness studies to guide future service planning.

Introduction

Robotic-assisted surgery (RAS) has been performed within the NHS for over two decades, but its adoption has increased exponentially over the last few years, reflecting that of wider international experience (1–3). While the initial focus was on complex oncological surgeries, particularly colorectal and upper gastrointestinal (UGI) resections, use is increasingly expanding into benign and day case surgery (4,5). This integration has been accelerated by strategic investment and guidance from central NHS policy and the Royal Colleges, which have identified robotics as a key direction for the future delivery of surgical therapies (1,2,6,7). Projections now suggest that by 2035 most minimally invasive procedures in high-income healthcare systems will be delivered robotically (2), mirroring the widespread adoption of laparoscopy in the late 20th century (7). In the UK, the NHS 10-year plan is for 9 in 10 minimally invasive operations to be performed with robotic assistance by 2035, with the understanding that upfront investment will bring long term benefits in faster operative times, improved recovery, and shorter hospital stays (6,8).

Inguinal hernia repair is one of the most commonly performed general surgical procedures in the UK (9,10). Established approaches include open repair and laparoscopic techniques such as transabdominal preperitoneal (TAPP) or totally extraperitoneal (TEP) repair (11). The laparoscopic approach has consistently demonstrated advantages in recovery, postoperative pain, and return to activity compared with open, particularly for patients with bilateral or recurrent hernias (10,11). However, a substantial proportion of inguinal hernia repairs continue to be performed via open approach (9,10,12).

Robotic inguinal hernia repair (RIHR) represents an evolution of minimally invasive surgery, building on the principles of laparoscopy while offering the potential advantages of three-dimensional vision, enhanced instrument articulation, and superior ergonomics (7,12,13). Early UK series have demonstrated feasibility and favourable perioperative outcomes (4,5), while international studies have demonstrated comparable and, in some cases, superior results relative to laparoscopy in terms of pain, recovery and complications (13–16). These benefits have been caveated with increased cost and operative times compared with traditional approaches (16–18). Adoption in the UK has therefore been cautious, but the recent governmental 10-year plan commits the NHS to developing robotic-assisted surgery as standard for a number of procedures including hernias, identifying it as key area for investment; the faster recovery, shorter hospital stays and improved efficiency are expected to offer significant benefits and help to reduce waiting lists (2,6,8).

Northumbria Healthcare NHS Foundation Trust has been an early adopter of robotic-assisted surgery in line with the NHS 10-year plan, establishing a dedicated benign robotic programme with more than 500 benign UGI cases performed. Within this framework, inguinal hernia repair was selected as an early day-case operation for robotic implementation. This study reports outcomes from the first 100 RIHR cases at our centre, compared with contemporaneous laparoscopic and open repairs. This represents one of the earliest UK single-centre comparative series of RIHR, and aims to provide insights into its feasibility, safety, and potential role within the day-case model.

Methods

We conducted a retrospective observational cohort study of all inguinal hernia repairs performed within the trust between 10 February 2022 and 5 September 2024, to encompass the completion of

the first 100 RIHR using the Da Vinci Xi platform. We compared the first 100 RIHR to 100 elective LIHR using the TAPP approach, and 100 elective OIHR.

Data collected included demographic variables (age, sex, body mass index [BMI], American Society of Anesthesiologists [ASA] grade), operative metrics (operative duration including console docking times for RIHR, and intra-operative complications) and rates of same-day discharge. Early postoperative outcomes within 30 days were assessed, including early recurrence (clinically or radiologically confirmed), re-attendance to hospital, re-admission, and return to theatre, as well as recorded complications (e.g., wound infection, urinary retention, seroma).

Learning curve analysis was performed using documented console times for each RIHR case. Times were plotted sequentially, with trends assessed using ordinary least squares (OLS) regression and a five-case rolling mean to illustrate short-term variation in performance.

All statistical analyses were conducted using IBM SPSS Statistics (version 27, IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation and compared using one-way ANOVA, with Tukey post-hoc testing where appropriate. Categorical variables were analysed with chi-squared or Fisher's exact tests, as appropriate. Length of stay was compared using the Kruskal-Wallis test. Statistical significance was defined as $p < 0.05$. Analyses were exploratory and were not adjusted for multiple comparisons.

A sensitivity analysis using propensity score matching (PSM) tested the robustness of the unmatched comparisons. Separate 1:1 nearest-neighbour matches were performed for RIHR versus LIHR and RIHR versus OIHR. Propensity scores were derived from logistic regression including age, ASA grade, BMI, sex, bilateral hernia, recurrent hernia, and prior abdominal surgery. A calliper width of 0.2 standard deviations of the logit of the propensity score was applied, without replacement. Balance was assessed using absolute standardised mean differences (SMDs), with values below 0.1 considered acceptable. Post-match outcomes evaluated were length of stay, 30-day re-admission, 30-day re-operation, intra-operative complications, and conversion.

This study was registered with the trust's clinical governance department and undertaken with Caldicott Guardian approval. As a retrospective service evaluation, formal research ethics committee approval was not required.

Results

Demographics

A total of 300 patients were included in the final analysis. Patients undergoing robotic repair were significantly younger (mean age 59.8 ± 16.3 years), than those in either the laparoscopic (64.1 ± 13.2) or open (70.1 ± 13.8) cohorts ($p<0.001$). There was also a statistically significant difference in ASA grade, with patients undergoing open repair having a higher mean ASA classification (2.21 ± 0.69) compared to either robotic (1.87 ± 0.61) or laparoscopic (1.82 ± 0.51) ($p = 0.0001$), suggesting a trend towards open repair being selected for older patients with greater comorbidity. There were no statistically significant differences in either sex distribution of patients (RIHR 84% male, LIHR 86% male, OIHR 84% male - $p = 0.665$) or mean BMI (RIHR 27.4±3.8, LIHR 26.9±3.9, OIHR 27.7±4.0; $p=0.35$).

Minimally invasive techniques were favoured for the management of bilateral hernias, which represented 26% of RIHR and 18% of LIHR cases, compared to only 4% of the OIHR cohort (χ^2 = 18.45, $p < 0.001$). The distribution of recurrent hernias was comparable across groups, accounting for 8% of repairs in the RIHR and OIHR cohorts and 10% of patients undergoing LIHR (χ^2 = 0.29, p = 0.866).

Table I: Demographics of patients undergoing inguinal hernia repair [a]

Variable	*Open (n=100)*	*Laparoscopic (n=100)*	*Robotic (n=100)*	*p-value*
Age, years (mean ± SD)	70.1 ± 13.8	63.5 ± 13.5	59.8 ± 16.3	<0.001
ASA score (mean ± SD)	2.21 ± 0.69	1.82 ± 0.51	1.87 ± 0.61	0.001
ASA I	15 (15%)	22 (22%)	28 (28%)	
ASA II	49 (49%)	73 (73%)	61 (61%)	
ASA III	36 (36%)	5 (5%)	11 (11%)	
ASA IV	0 (0%)	0 (0%)	0 (0%)	
ASA V	0 (0%)	0 (0%)	0 (0%)	
BMI, kg/m^2 (mean ± SD)	27.7 ± 4.0	26.9 ± 3.9	27.4 ± 3.8	0.353
Bilateral repair, n (%)	4 (4%)	18 (18%)	26 (26%)	<0.001
Male (%)	84 (84%)	86 (86%)	84 (84%)	0.665
Female (%)	16 (16%)	14 (14%)	16 (16%)	0.665
Previous Abdominal Surgery, n (%)	18 (18%)	31 (31%)	20 (20%)	0.063
Recurrent, n (%)	8 (8%)	10 (10%)	8 (8%)	0.866

a. Continuous variables are reported as mean ± SD and compared using one-way ANOVA; categorical variables are reported as percentages and compared using chi-squared tests or Fisher's exact test as appropriate. P-values correspond to overall group comparison

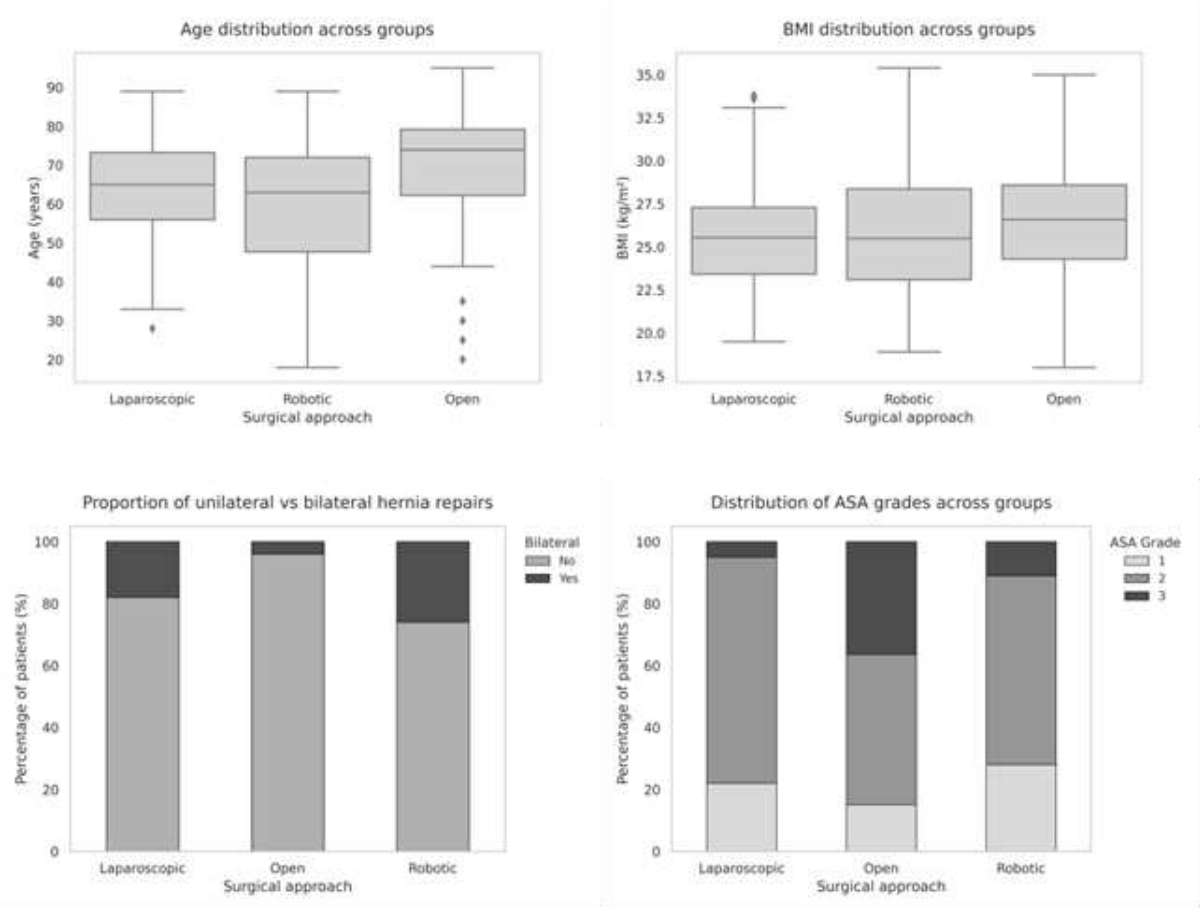


Figure I: Demographics of patients undergoing inguinal hernia repair

Operative Time

Operative duration, measured in each group from time of first incision to skin closure, differed significantly between the three approaches. OIHR had the longest mean time (56.1 ± 17.7 minutes), while LIHR was the quickest (43.2 ± 17.3 minutes). RIHR fell in between at 48.9 ± 25.1 minutes, although the operative times reduced over the timeframe of the study, in keeping with a learning curve effect (22-172 minutes). A one-way ANOVA confirmed a significant effect of operative modality on duration ($F = 10.17$, $p < 0.0001$).

Stratifying by unilateral and bilateral repair showed a similar pattern. For unilateral cases, LIHR remained the fastest on average (42.4 ± 17.4 minutes), followed by RIHR (46.2 ± 19.9 minutes) and then OIHR (53.8 ± 19.2 minutes), a statistically significant difference ($F = 8.5$, $p = 0.020$). Tukey post-hoc testing showed OIHR was slower than both LIHR (mean difference 11.4 minutes, $p < 0.001$) and RIHR (mean difference 7.6 minutes, $p = 0.032$); however, there was no significant difference between the minimally invasive groups.

Bilateral cases showed the same pattern as unilateral repairs, with OIHR taking longest on average (68.8 ± 14.4 minutes), followed by RIHR (63.8 ± 30.0 minutes) and then LIHR (48.5 ± 17.1 minutes). Although laparoscopic repair appeared quicker, the differences did not reach statistical significance ($F = 3.14$, $p = 0.053$), reflecting the smaller cohort size. Post-hoc testing likewise found no significant pairwise differences (all $p > 0.14$). While underpowered, these results suggest that the trend observed in unilateral repairs may extend to bilateral cases.

A two-way ANOVA confirmed that both surgical modality ($F = 9.0$, $p < 0.001$) and whether the repair was bilateral or unilateral ($F = 15.7$, $p < 0.001$) independently influenced the operative time. However, there was no significant interaction effect ($F = 1.32$, $p = 0.27$), indicating that the relative performance of each modality was consistent across unilateral and bilateral repairs.

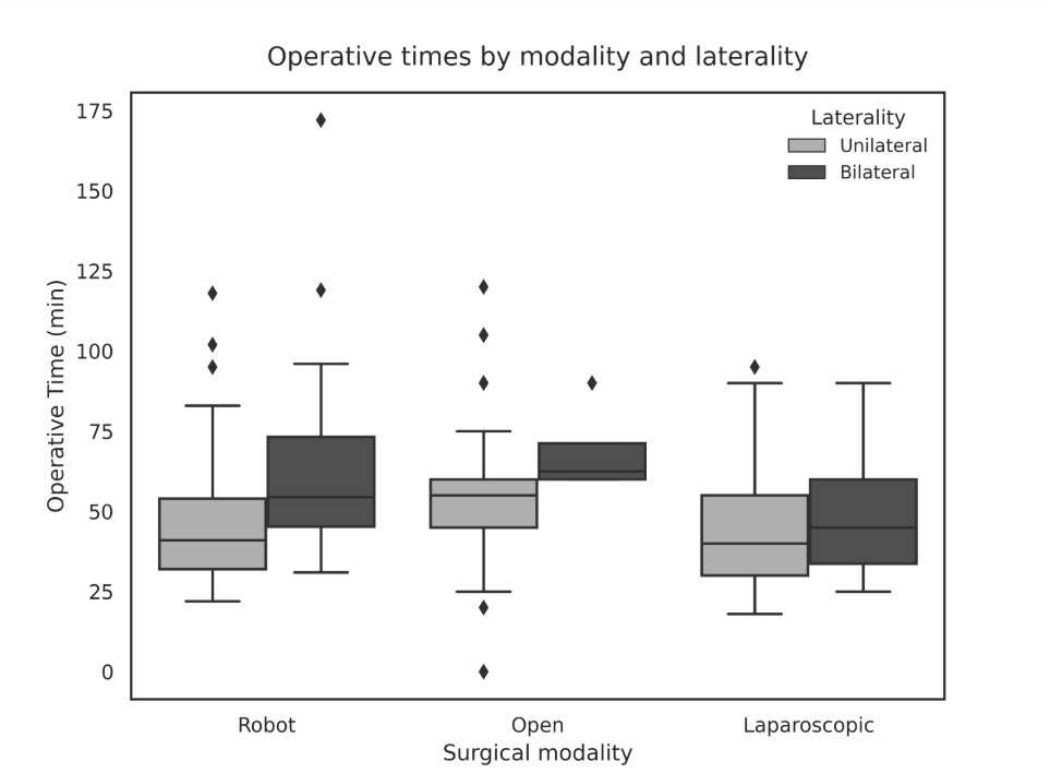


Figure II:Box and whisker plot showing operative times by modality and laterality

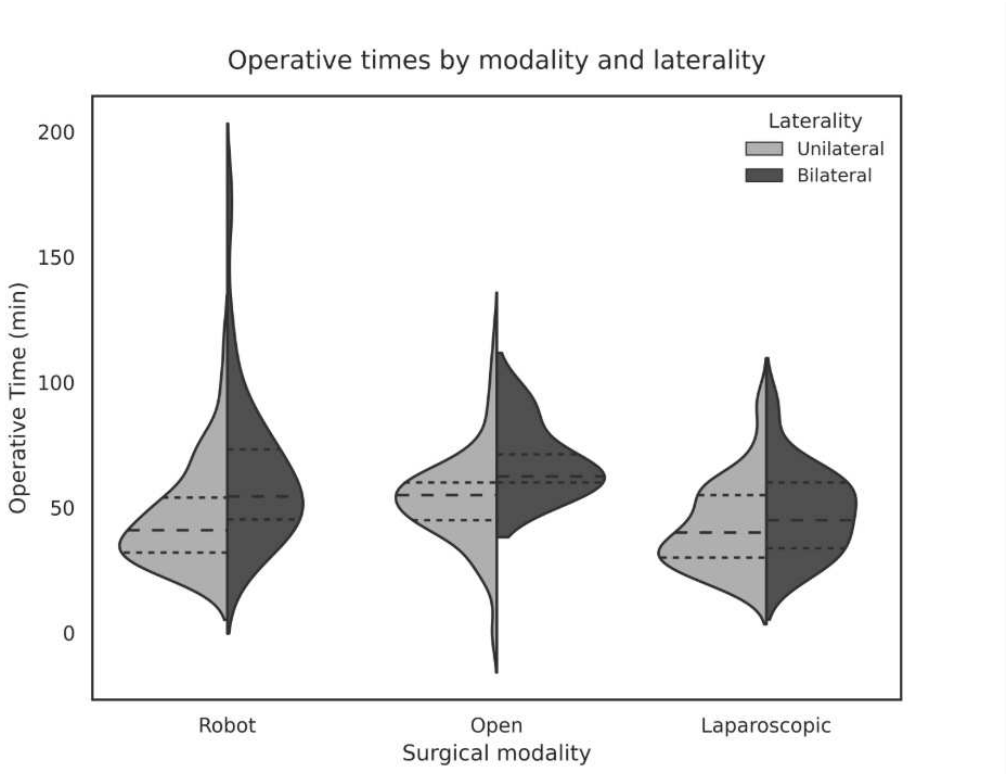


Figure III: Violin plot showing operative times by modality and laterality

Learning Curve

Console times showed a consistent downward trend across all four surgeons, reflecting progressive improvements in efficiency with increasing case experience. Linear regression analysis demonstrated negative slopes for each operator. Statistically significant reductions were observed for Surgeon 1 (–0.47 minutes per case; 95% CI –0.82 to –0.12; p = 0.01; R^2 = 0.18) and Surgeon 4 (–0.87 minutes per case; 95% CI –1.43 to –0.31; p = 0.004; R^2 = 0.25). Surgeons 2 (–0.32 minutes per case; p = 0.03; R^2 = 0.12) and 3 (–0.21 minutes per case; p = 0.26; R^2 = 0.05) showed similar downward slopes, although these were weaker and less consistent in reaching statistical significance.

Correlation analyses supported these findings. Significant negative associations between case order and console time were confirmed for Surgeon 1 (ρ = –0.36; p = 0.02) and Surgeon 4 (ρ = –0.41; p = 0.01), while non-significant but directionally consistent correlations were observed for Surgeons 2 (ρ = –0.22; p = 0.14) and 3 (ρ = –0.18; p = 0.20).

Early versus late case comparisons further illustrated the learning effect. Median console time fell from 60 to 41 minutes for Surgeon 1 (Δ –19 minutes; p = 0.04) and from 61 to 46 minutes for Surgeon 4 (Δ –15 minutes; p = 0.01). Similar trends were seen for Surgeons 2 (43 to 27 minutes; Δ –16 minutes; p = 0.07) and 3 (40 to 34 minutes; Δ –6 minutes; p = 0.18), although these did not achieve statistical significance.

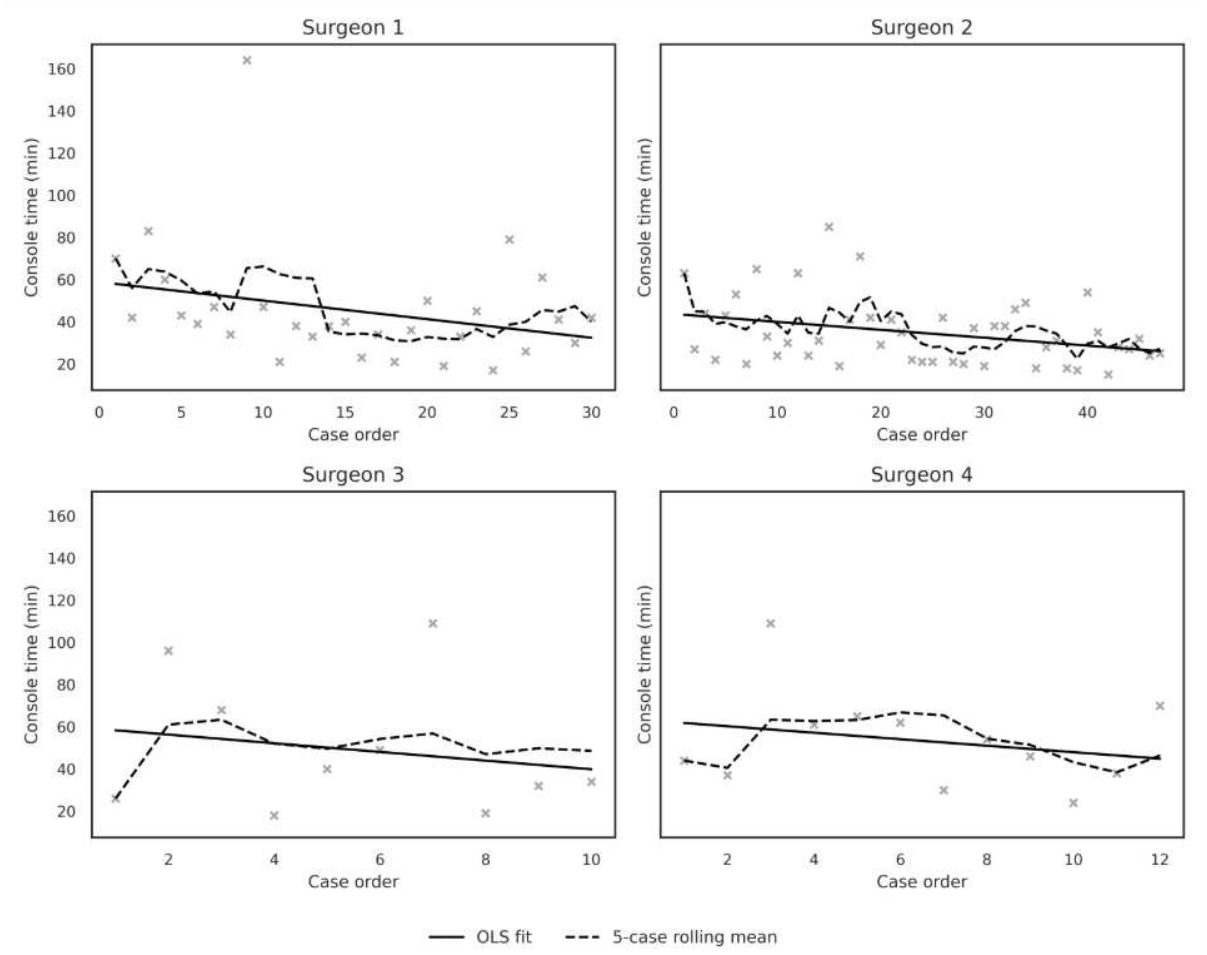


Figure IV: Console time by case number for each surgeon

Table II: Linear regression analysis for each surgeon

Surgeon	*Slope (min/case)*	*95% CI*	*p-value*	*R^2*
Surgeon 1	-0.47	-0.82 to -0.12	0.01	0.18
Surgeon 2	-0.32	-0.7 to -0.05	0.03	0.12
Surgeon 3	-0.21	-10.48 to 6.37	0.26	0.05
Surgeon 4	-0.87	-1.43 to -0.31	0.004	0.25

Operative Metrics

Intraoperative complications were rare, occurring in one patient in each group (1%). In both the laparoscopic and robotic cohorts, the complication was an injury to the inferior epigastric artery, which was controlled with ligaclips in the LIHR patient and suture ligation in the RIHR patient. Conversion to open occurred in four laparoscopic cases (4%), while none were recorded in the robotic group. This difference did not reach statistical significance (Fisher's exact test, p = 0.12)

Marked differences were seen in mesh fixation strategy (χ^2 = 295.1, df = 8, p<0.000001). Self-adhesive mesh was used in 28% of OIHR, 12% of LIHR, and 8% of RIHR cases. Suture fixation

predominated in OIHR (72%) and RIHR (61%) but was uncommon in LIHR (6%); tackers were employed in 78% of LIHR cases and in none of the RIHR or OIHR groups. No fixation was performed in 30% of RIHR cases versus 4% of LIHR cases, with no such cases in the OIHR group.

The technique employed for peritoneal closure differed markedly between the minimally invasive approaches ($\chi^2 = 136.1$, df = 2, $p < 0.001$). Tackers were used in 80% of LIHR cases but in none of the RIHR cases, which universally used sutured closure compared with 19% of LIHR cases. A single LIHR case used glue.

Short-Term Outcomes (30-day)

The median length of stay (LOS) was 0 days across all groups, reflecting a predominantly day-case pathway. Day-case discharge was achieved in 92% of RIHR, 97% of LIHR, and 86% of OIHR patients, a statistically significant difference ($\chi^2 = 7.94$, $p = 0.019$). This likely reflects a frailer elderly population undergoing OIHR, evidenced in the higher average age and ASA scores of the OIHR cohort. There was no significant difference between the LIHR and RIHR groups, reflecting a consistently high rate of same day discharge in the patients undergoing minimally invasive surgery.

At 30-day follow-up, outcomes were favourable across all three surgical modalities. Unplanned re-attendance occurred in 8% of OIHR, 11% of RIHR, and 7% of LIHR patients, with no significant difference between groups ($\chi^2 = 1.09$, $p = 0.58$). Most common reasons for presentation were minor wound issues (erythema, seroma, superficial dehiscence) or urinary retention, corresponding to Clavien Dindo grade I.

Hospital readmission within 30 days was recorded in 4% of OIHR, 2% of RIHR, and 0% of LIHR patients ($\chi^2 = 4.08$, $p = 0.13$). Re-operation was required in 2% of OIHR cases for haematoma formation (Clavien Dindo IIIB), and in none of the RIHR or LIHR cohorts ($\chi^2 = 4.03$, $p = 0.13$).

One postoperative death occurred in the OIHR cohort (1%), in a multi-comorbid patient who developed multi organ failure and sepsis unrelated to the index procedure. No mortality occurred in the robotic or laparoscopic groups ($\chi^2 = 2.01$, $p = 0.37$). Hernia recurrence within 30 days was documented in 2% of OIHR, 1% of RIHR, and 0% of LIHR patients ($\chi^2 = 2.02$, $p = 0.36$).

No statistically significant differences were observed in any 30-day outcome measure, suggesting comparable short-term safety across robotic, laparoscopic, and open inguinal hernia repair, although the study was not powered to detect differences in uncommon events.

Propensity score matching

The sensitivity analysis generated 96 matched pairs for RIHR versus LIHR and 95 pairs for RIHR versus OIHR. Baseline covariates achieved improved balance across age, sex, BMI, ASA grade, bilateral hernia, recurrent hernia, and prior abdominal surgery, with most standardised mean differences below 0.1 in the LIHR comparison and below 0.3 in the OIHR comparison. Post-match outcomes, including length of stay, 30-day readmission, re-operation, intra-operative complications, and conversion, remained directionally consistent with the unmatched analysis. These findings support the robustness of the unmatched results, although residual imbalance and modest sample sizes mean that residual bias cannot be excluded.

Discussion

This study reports the first UK series to directly compare robotic, laparoscopic, and open inguinal hernia repair. We found that RIHR is both safe and feasible in an NHS day case setting, with RIHR achieving comparable rates of same day discharge and thirty-day outcomes to LIHR, and both minimally invasive techniques performing significantly better than OIHR consistent with national and international data (16,19,20). It is notable that RIHR delivered these results despite being in its early adoption phase, underlining its feasibility even during the learning curve.

Complication and conversion rates with RIHR were low. We recorded no conversions or instances of emergency undocking in the robotic group compared with 4% in the laparoscopic cohort. Although this difference was not statistically significant, the laparoscopic conversion rate is in keeping with published data, and the finding is consistent with the hypothesis that the improved visualisation and dexterity of the robotic platform may reduce the need to abandon minimally invasive repair (13,15). Although the numbers in our study are small, a recent cohort study from the United States reviewing 65,039 emergency inguinal hernia repairs noted significantly lower conversion rates in RIHR compared to LIHR (2.4% versus 10.7%), along with reduced hospital stays (21). Our results are consistent with a growing evidence base suggesting that RIHR could offer improved patient outcomes in challenging cases, and common elective procedures such as inguinal hernia repair provide essential opportunities for developing the robotic skills required to safely undertake the more complex operations, from emergency cases to anti-reflux and bariatric operations.

Concerns about robotics often focus on operative times. In our series, RIHR took longer than laparoscopy but was quicker than open repair, with greater variation that likely reflects the introduction of new techniques. Importantly, we observed a downward trend in console times, in keeping with international learning curves across 20–35 cases (5,15,22), with one study reporting decreasing operative times even after 61 cases (17). These gains were most evident among higher volume surgeons, highlighting the need for structured training and case concentration. Notably, the median late case console times were lower than the median laparoscopic times, suggesting that in future, RIHR has the potential to be not just comparable but possibly quicker than LIHR.

Marked differences were observed in mesh fixation and peritoneal closure technique. Laparoscopic repair relied heavily on tackers, whereas robotic repair facilitated suture fixation and routine sutured peritoneal closure. These patterns are consistent with wider literature highlighting the robotic platform's advantages in intracorporeal suturing (15). Meta-analyses indicate that tacker use may expedite surgery but is associated with increased cost and potentially higher rates of chronic postoperative pain (23,24). The ability to suture mesh and close the peritoneal flap robotically may therefore carry both clinical and economic benefits. However, this requires further assessment of long-term chronic pain rates and cost-effectiveness. This was not covered within the remit of this study.

The launch of the British Hernia Society registry (25) will be central to confirming these results across the UK and to providing much-needed data on long-term outcomes such as recurrence, chronic pain, and patient-reported measures. Both recurrence and chronic pain remain essential indicators of hernia surgery success, and international series increasingly highlight the importance of patient-reported outcomes such as quality of life and return to activity. These should be a focus for future UK research.

From a service perspective, our findings show that RIHR can be integrated into day-case pathways without reducing efficiency. Overall, international experience supports the generalisability of our findings. RIHR delivers short term outcomes on par with laparoscopy in health systems with well-developed minimally invasive pathways (12,13,15). Its wider value will depend on system level factors including case selection, training, and ergonomics. Recent statements from professional bodies stress that open, laparoscopic, and robotic approaches can all deliver excellent outcomes when used appropriately, reinforcing the principle that the best approach should be tailored to the patient and the institution (1).

Cost is perhaps the most widely debated aspect of robotics. High capital and maintenance costs are well recognized (16), but these must be considered alongside potential efficiency gains, fewer complication related costs, and benefits linked to surgeon ergonomics. Within the UK, governmental policy and NHS plan for robotic surgery recognises the capital required but affirms that the innovation and improved patient outcomes justifies the investment at a national level (1,2,8). Cost therefore was not a focus of this feasibility study. However, our observation that efficiency comparable to laparoscopy can be achieved early within adoption suggests that cost neutrality may be attainable under certain conditions. Given that our cohort reflects the early adoption phase, when operative times were still falling, a detailed cost comparison at this stage would likely have been unrepresentative and potentially misleading. Robust cost evaluation requires stable operative performance, standardised instrumentation usage, and mature workflow efficiency, none of which had fully developed during the study period. As console times continued to decline beyond the first 100 cases, future cost modelling will be more accurate once performance has plateaued. We therefore view a detailed NHS-specific economic analysis as a critical next step, but one best undertaken once the learning curve has been completed. In particular, the costs in future may reduce as more companies enter a growing market, driving competitive pricing, and the cost per unit improves after initial start-up investments and with more robotic infrastructure. Ultimately, robust NHS specific modelling will be required.

Limitations

This study has several limitations. It was retrospective, single centre, and based on a modest sample size, which reduced the ability to detect rare outcomes such as mortality and recurrence. Patient selection may also have influenced the choice of surgical modality. Allocation to operative approach was not randomised, and patients undergoing open repair were older with higher ASA grades, so selection bias is likely despite propensity matching. Robotic cases represent the early learning curve of four surgeons, and console time is not directly comparable with laparoscopic operative time. Differences in fixation and closure technique may reflect institutional practice patterns. In addition, our follow up was limited to 30 days and did not capture long term recurrence, chronic pain, return to activity, or patient reported outcomes.

Despite these limitations, this series provides early evidence that RIHR can be delivered safely and efficiently within a day case model. Thirty-day outcomes were comparable to LIHR and OIHR, and operative efficiency improved with experience. These findings support the growing international evidence base and highlight the need for multicentre prospective studies to better define the role of robotics in NHS hernia surgery.

Although PSM reduced baseline imbalances, matched sample sizes were modest and residual confounding cannot be excluded, so matched analyses should be interpreted as sensitivity assessments rather than definitive comparisons. Analyses were exploratory and unadjusted for multiple comparisons.

Future work should incorporate patient-reported outcome measures, chronic pain assessment, and long-term recurrence (10,12,24). Larger multicentre studies and national registry data such as the British Hernia Society Registry (25) will be invaluable in defining the role of RIHR across diverse settings and in evaluating its scalability beyond high-volume robotic centres.

Conclusion

Robotic inguinal hernia repair can be delivered safely and efficiently within an NHS day-case framework. In this early UK series, short-term outcomes were equivalent to laparoscopic repair and superior to open repair in terms of recovery and same-day discharge. Although operative times were initially longer than laparoscopy, these improved with experience, consistent with international learning curves and later cases were faster than the median laparoscopic time. Early efficiency suggests that wider adoption may not compromise and even improve theatre utilisation. Complication rates were low and there were no conversions compared with 4 in the laparoscopic group, which suggests that RIHR may have better outcomes in more challenging cases. Larger multicentre studies and registry data are now needed to assess long-term outcomes, patient-reported measures, and economic impact, and to define the appropriate role of robotics in UK hernia surgery.

Author Contributions

Stuart Cowie, Robyn Bartlett, and Olivia Kent collected the data. Stuart Cowie performed the data analysis. Stuart Cowie and Olivia Kent wrote and revised the manuscript. Liam Horgan and Edward J Nevins supervised the project and recommended amendments. All authors read and approved the final manuscript.

Competing interests

The authors declare no competing interests. The authors have no relevant financial or non-financial interests to disclose.

Funding

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

References.

1. RCS England. Royal College of Surgeons [Internet]. [cited 2026 Aug 16]. Robotic-assisted surgery: A pathway to the future. Available from: https://www.rcseng.ac.uk/standards-and-research/standards-and-guidance/good-practice-guides/robotic-assisted-surgery/

2. NHS England, Getting It Right First Time (GIRFT). Implementation of robotic-assisted surgery (RAS) in England [Internet]. London: NHS England; 2025 May [cited 2026 Oct 8]. Available from:

https://gettingitrightfirsttime.co.uk/wp-content/uploads/2025/05/FINAL_NHS-England-and-GIRFT-implementation-of-robotically-assisted-surgery-in-England_06-05-2025.pdf

3. Sheetz KH, Claflin J, Dimick JB. Trends in the Adoption of Robotic Surgery for Common Surgical Procedures. JAMA Netw Open. 2020 Jan 3;3(1):e1918911. doi:10.1001/jamanetworkopen.2019.18911 PubMed PMID: 31922557; PubMed Central PMCID: PMC6991252.

4. Greene K, Nevins E, Akharaekpanya T, Bawa S, Horgan L. Initial experience of benign upper gastrointestinal robotic-assisted surgery: first 200 cases and early postoperative outcomes. Ann R Coll Surg Engl. 2025 Nov;107(8):549–54. doi:10.1308/rcsann.2024.0093 PubMed PMID: 40178389; PubMed Central PMCID: PMC12578583.

5. Latif J, Brazkiewicz M, Inan I, Muysoms F, Bhatti I, Awan A. Outcomes During the Learning Curve and Feasibility of Implementing the European Hernia Society Recommendation Guidelines for Robotic Abdominal Wall Surgery Within a UK Centre. J Abdom Wall Surg. 2025 Aug 6;4:15008. doi:10.3389/jaws.2025.15008 PubMed PMID: 40842882; PubMed Central PMCID: PMC12364726.

6. Department of Health and Social Care. Fit for the future: 10 Year Health Plan for England [Internet]. CP 1350. London: Department of Health and Social Care; 2025 Jul 3 [cited 2026 Oct 8]. Available from: https://www.gov.uk/government/publications/10-year-health-plan-for-england-fit-for-the-future

7. Brodie A, Vasdev N. The future of robotic surgery. Ann R Coll Surg Engl. 2018 Sep;100(Suppl 7):4–13. doi:10.1308/rcsann.supp2.4 PubMed PMID: 30179048; PubMed Central PMCID: PMC6216754.

8. NHS England. NHS England » Millions to benefit from NHS robot drive [Internet]. 2025 [cited 2026 Aug 16]. Available from: https://www.england.nhs.uk/2025/06/millions-to-benefit-from-nhs-robot-drive/

9. Pawlak M, Tulloh B, de Beaux A. Current trends in hernia surgery in NHS England. Ann R Coll Surg Engl. 2020 Jan;102(1):25–7. doi:10.1308/rcsann.2019.0118 PubMed PMID: 31418302; PubMed Central PMCID: PMC6937612.

10. Stabilini C, van Veenendaal N, Aasvang E, Agresta F, Aufenacker T, Berrevoet F, et al. Update of the international HerniaSurge guidelines for groin hernia management. BJS Open. 2023 Sep 5;7(5):zrad080. doi:10.1093/bjsopen/zrad080 PubMed PMID: 37862616; PubMed Central PMCID: PMC10588975.

11. Bittner R, Montgomery MA, Arregui E, Bansal V, Bingener J, Bisgaard T, et al. Update of guidelines on laparoscopic (TAPP) and endoscopic (TEP) treatment of inguinal hernia (International Endohernia Society). Surg Endosc. 2015 Feb;29(2):289–321. doi:10.1007/s00464-014-3917-8 PubMed PMID: 25398194; PubMed Central PMCID: PMC4293469.

12. Huerta S, Garza AM. A Systematic Review of Open, Laparoscopic, and Robotic Inguinal Hernia Repair: Management of Inguinal Hernias in the 21st Century. J Clin Med. 2025 Feb 4;14(3):990. doi:10.3390/jcm14030990 PubMed PMID: 39941661; PubMed Central PMCID: PMC11818799.

13. Aiolfi A, Cavalli M, Micheletto G, Bruni PG, Lombardo F, Perali C, et al. Robotic inguinal hernia repair: is technology taking over? Systematic review and meta-analysis. Hernia J Hernias Abdom Wall Surg. 2019 Jun;23(3):509–19. doi:10.1007/s10029-019-01965-1 PubMed PMID: 31093778.

14. Charles EJ, Mehaffey JH, Tache-Leon CA, Hallowell PT, Sawyer RG, Yang Z. Inguinal hernia repair: is there a benefit to using the robot? Surg Endosc. 2018 Apr;32(4):2131–6. doi:10.1007/s00464-017-5911-4 PubMed PMID: 29067575; PubMed Central PMCID: PMC10740385.

15. Solaini L, Cavaliere D, Avanzolini A, Rocco G, Ercolani G. Robotic versus laparoscopic inguinal hernia repair: an updated systematic review and meta-analysis. J Robot Surg. 2022 Aug;16(4):775–81. doi:10.1007/s11701-021-01312-6 PubMed PMID: 34609697; PubMed Central PMCID: PMC9314304.

16. Lorenz WR, Holland AM, Adams AS, Mead BS, Scarola GT, Kercher KW, et al. Open versus laparoscopic versus robotic inguinal hernia repair: A propensity-matched outcome analysis. Surgery. 2025 Mar;179:108895. doi:10.1016/j.surg.2024.08.054 PubMed PMID: 39472265.

17. Kudsi OY, Bou-Ayash N, Gokcal F, Crawford AS, Chung SK, Chudner A, et al. Learning curve of robot-assisted transabdominal preperitoneal (rTAPP) inguinal hernia repair: a cumulative sum (CUSUM) analysis. Surg Endosc. 2022 Mar;36(3):1827–37. doi:10.1007/s00464-021-08462-6 PubMed PMID: 33825019.

18. Prabhu AS, Carbonell A, Hope W, Warren J, Higgins R, Jacob B, et al. Robotic Inguinal vs Transabdominal Laparoscopic Inguinal Hernia Repair: The RIVAL Randomized Clinical Trial. JAMA Surg. 2020 May 1;155(5):380–7. doi:10.1001/jamasurg.2020.0034 PubMed PMID: 32186683; PubMed Central PMCID: PMC7081145.

19. Joyner J, Ayyaz FM, Cheetham M, Briggs TWR, Gray WK. Day-case and in-patient elective inguinal hernia repair surgery across England: an observational study of variation and outcomes. Hernia J Hernias Abdom Wall Surg. 2023 Dec;27(6):1439–49. doi:10.1007/s10029-023-02893-x PubMed PMID: 37851291.

20. Joyner J, Ayyaz FM, Cheetham M, Briggs TWR, Gray WK. Factors associated with conversion from day-case to in-patient elective inguinal hernia repair surgery across England: an observational study using administrative data. Hernia J Hernias Abdom Wall Surg. 2024 Apr;28(2):555–65. doi:10.1007/s10029-023-02949-y PubMed PMID: 38347244.

21. Lunardi N, Abou-Zamzam A, Florecki KL, Chidambaram S, Shih IF, Kent AJ, et al. Robotic Technology in Emergency General Surgery Cases in the Era of Minimally Invasive Surgery. JAMA Surg. 2024 May 1;159(5):493–9. doi:10.1001/jamasurg.2024.0016

22. Hayward RK, Smellie WJB, Sanchez-Thompson N, Warren OJ. BHSeP6 Cumulative sum analysis of the robotic inguinal hernia repair learning curve. BJS. 2025 Jan 23;112(Supplement_3):znae323.010. doi:10.1093/bjs/znae323.010

23. Pompeu BF, Almiron da Rocha Soares G, Pereira Silva M, Ponte Farias AG, Oliveira de Sousa Silva R, Mazzola Poli de Figueiredo S. Suture versus tacks in minimally invasive transabdominal preperitoneal inguinal repair: a meta-analysis of randomized controlled trials. Surg Endosc. 2024 Sep 1;38(9):4858–68. doi:10.1007/s00464-024-11138-6

24. Andresen K, Rosenberg J. Management of chronic pain after hernia repair. J Pain Res. 2018;11:675–81. doi:10.2147/JPR.S127820 PubMed PMID: 29670394; PubMed Central PMCID: PMC5896652.

25. British Hernia Society. British Hernia Society Registry [Internet]. [cited 2026 Aug 16]. British Hernia Society Registry. Available from: https://www.britishherniasociety.org/british-hernia-society-registry/