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Robotic-Assisted Emergency General Surgery: Feasibility and Outcomes in Experienced Hands

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Abstract

Background/Objectives Robotic-assisted surgery has transformed elective general surgery, offering well-documented benefits for both surgeons and patients. However, its application in emergency settings remains underexplored. This study aims to evaluate the feasibility, safety, and effectiveness of robotic surgery in emergency general surgical cases when performed by an experienced surgical team. Methods: This observational, single-center study included 12 patients who underwent emergency robotic surgery at a high-volume tertiary care institution. All procedures were performed by the same surgeon with extensive experience in minimally invasive and robotic techniques. Demographic data and perioperative outcomes were prospectively recorded. Results: The median patient age was 73 years (range 38–91), with a median BMI of 27 kg/m² (range 25–34). The most common indications were obstructing colon tumors (66.7%) and incarcerated hernias (16.7%). The median operative time was 3 hours (range 2–6). There were no conversions to open or laparoscopic surgery. Minor postoperative complications (Clavien-Dindo Grade I–II) occurred in 2 patients (16.7%) and were managed conservatively. One intraoperative complication (ureteric injury) occurred and was identified and managed robotically without converting to open. No patient required postoperative intensive care. The median time to first flatus and oral intake was 2 days (range 1–3). The median length of hospital stay was 2 days (range 1–11), with no 90-day readmissions or mortality. Conclusions: Robotic-assisted emergency general surgery appears both feasible and safe when performed by an experienced surgical team. The absence of conversions, low complication rates, and favorable postoperative outcomes support its use in selective emergency cases without compromising patient safety or recovery.

Keywords: robotic-assisted surgery; emergency surgery; emergency robotic surgery; minimally invasive surgery; surgical expertise

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1. Introduction

Robotic-assisted surgery has become an increasingly favored approach for elective general and colorectal procedures—ranging from routine interventions such as cholecystectomy to complex multisegmental colectomies for colon cancer [Petropoulou 2024]. Its advantages are well established, including enhanced visualization, improved precision, and superior ergonomics for the surgeon. However, its role in emergency settings, where rapid decision-making and procedural adaptability are essential, remains largely underexplored.

Emergency surgery presents unique challenges: patients often arrive with acute, life-threatening conditions requiring urgent intervention, frequently with limited time for preoperative optimization or imaging [Moparthi 2024]. This is further complicated in patients with multiple comorbidities or multisystem involvement, where unpredictable intraoperative findings—such as extensive adhesions, bowel edema, or active bleeding—demand flexibility in surgical strategy [Blank 2023]. Common emergency general surgical scenarios include bowel perforation and trauma, where precise debridement and preservation of viable tissue are critical to patient outcomes [Lansford 2023].

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To date, the majority of emergency surgical procedures are performed via open approaches, although experienced minimally invasive surgeons may attempt laparoscopic techniques [Lupinacci 2015]. However, laparoscopy can be particularly challenging in obese patients, those with prior abdominal surgeries, or in anatomically restricted areas such as the pelvis [Madhok 2021]. The use of rigid, non-articulating instruments further limits maneuverability in cases with dense adhesions or altered anatomy [Matsui 2014].

Robotic-assisted surgery offers a potential solution to these limitations. With its articulated instruments, stable 3D visualization, and greater dexterity, it has been shown to reduce conversion rates, minimize complications, and enhance overall surgical performance—even in complex cases [Kozonis 2024]. Moreover, many emergency patients carry significant comorbid burdens—such as cardiovascular disease, diabetes, or chronic respiratory conditions—which elevate the risk of postoperative complications [Zambouri 2007]. For these patients, the minimally invasive nature of robotic surgery may offer crucial advantages: smaller incisions, faster recovery, reduced hospital stays, and earlier mobilization [Lee 2014].

Barriers to broader adoption of robotic platforms in emergency settings include concerns regarding setup time, cost, and limited access outside regular operating hours. However, when these systems are available and operated by experienced surgical teams, such limitations may be mitigated.

Given our team's extensive experience in robotic colorectal and general surgery, we sought to evaluate the real-world use of this technology in urgent conditions. To our knowledge, this is among the few clinical series specifically assessing outcomes of robotic-assisted surgery in unselected emergency general surgical cases.

We present a prospective case series evaluating robotic surgery in diverse emergency presentations, aiming to assess feasibility, safety, and clinical outcomes—and to help define its role in the evolving landscape of acute care surgery.

2. Methods

2.1. Study Design and Ethical Compliance

This was a prospective, observational, single-center study conducted at a high-volume tertiary care hospital between [insert study period, e.g., January 2020 and December 2024]. All adult patients undergoing robotic-assisted surgery for non-elective general surgical indications—including bowel obstruction, incarcerated or strangulated hernia, or obstructing malignancy—were consecutively included without exclusion criteria.

All procedures were performed by the same board-certified minimally invasive and robotic surgeon, supported by a dedicated and experienced robotic surgical team. The console surgeon had performed over 250 robotic procedures and was the only general surgeon performing robotic emergency surgery at the institution, which had completed over 150 robotic general surgery cases.

Patients were followed postoperatively for a minimum of one year for benign conditions and five years for oncologic indications. Ethical approval was obtained from the Institutional Review Board, and written informed consent was obtained from all participants. The study adhered to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines [von Elm 2007].

2.2. Study Variables

Collected demographic data included sex, age, body mass index (BMI), surgical diagnosis, and prior abdominal surgery. Operative variables included procedure type, operative time (OT), whether a drain was placed, and total robotic case volumes by the surgeon and institution. Primary outcomes were conversion to open or laparoscopic surgery, intraoperative and postoperative complications (with their management), ICU admission, time to first flatus, time to mobilization, time to first oral intake, length of stay (LOS), 90-day readmission, and 90-day mortality.

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2.3. Data Sources and Measurement

All data were prospectively collected from electronic hospital records and patient charts. Operative time was defined as the interval from initial skin incision to final skin closure. Complications were classified according to the Clavien-Dindo system [Dindo 2004].

Time to first flatus was defined as the time to first patient-reported passage of gas. Time to mobilization referred to the time from surgery completion to first ambulation. Time to oral intake was defined as the time from surgery to first permitted oral consumption. LOS was calculated from admission to discharge.

No intraoperative or postoperative data were missing, and complete follow-up data were available for all patients included in the analysis.

2.4. Bias Minimization

To minimize selection bias, all eligible patients undergoing robotic-assisted emergency surgery during the study period were included. The single-center nature of the study ensured a consistent institutional environment, while all procedures were performed by the same experienced robotic surgeon and team, reducing performance variability.

Prospective data collection eliminated recall bias. Standardized definitions and validated grading systems (e.g., Clavien-Dindo) were employed to reduce interpretation bias. Clinical and radiological follow-up was used to identify complications, reducing the risk of underreporting. The study was reported in compliance with the STROBE checklist to enhance methodological transparency.

2.5. Statistical Analysis

Continuous variables are presented as mean ± standard deviation (SD), followed by median and range: mean (SD) [median (range)]. Categorical variables are reported as absolute counts and percentages: N (%). Descriptive statistics were calculated using IBM SPSS Statistics for Windows, Version XX (IBM Corp., Armonk, NY). This was a single-arm, descriptive study with no control group.

3. Results

3.1. Population and Preoperative Details

A total of 12 patients were included in the study, of whom only one (8.3%) was female. The mean age was 68.7 ± 18.0 years, with a median of 74 years (range 38–91). The mean body mass index (BMI) was 27.8 ± 2.6 kg/m², with a median of 27 (range 25–34).

Six patients (50%) had a history of prior abdominal surgical interventions, regardless of whether the previous procedures were open or minimally invasive. The most common indication for emergency surgery was obstructing colon tumor (n = 7; 58.3%), followed by incarcerated hernia (n = 2; 16.7%). Additional demographic and diagnostic details are summarized in **Table 1**.

Table 1. Patient demographics and preoperative characteristics.

No.	Sex	Age (y)	BMI (kg/m²)	Previous surgery	Diagnosis – surgical indication
1	F	91	28.0	Yes	Obstructing transverse colon tumor
2	M	38	26.0	No	Obstructing upper rectal tumor
3	M	55	29.3	Yes	Obstructing sigmoid colon tumor
4	M	45	34.0	No	Acute diverticulitis
5	M	81	28.0	No	Obstructing cecal tumor
6	M	64	26.0	No	Ureteric injury
7	M	82	27.0	Yes	Incarcerated epigastric hernia

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8	M	88	27.0	Yes	Obstructing ascending colon tumor
9	M	74	30.0	Yes	Obstructing rectal tumor
10	M	81	25.0	Yes	Bleeding ascending colon tumor
11	M	57	27.0	No	Incarcerated left inguinal hernia

BMI = body mass index; y = years.

3.2. Intraoperative and Postoperative Outcomes

The robotic-assisted procedures performed are summarized in **Table 2**, with colectomies (58.3%) and incarcerated hernias (16.7%) being the most frequent. The mean operative time was 3.5 ± 1.1 hours, with a median of 3 hours (range 2–6). No conversions to open or laparoscopic surgery were required, and intraoperative drain placement was performed in 5 patients (41.7%).

No patients required postoperative admission to the intensive care unit (ICU). Two patients (16.7%) experienced minor postoperative complications (Clavien-Dindo Grade I–II):

- A 55-year-old man (BMI: 29.3 kg/m^2) with two **synchronous tumors** , a cecal tumour and an obstructing sigmoid colon tumor and a history of recurrent colonic liposarcomas underwent a right colectomy with concurrent sigmoidectomy, extensive adhesiolysis, and resection of a locoregional recurrence. He developed a superficial surgical site infection, which was treated with intravenous cefuroxime and metronidazole.
- A 64-year-old man (BMI: 29.3 kg/m^2) with a low rectal tumor underwent an elective low anterior resection with a defunctioning ileostomy. He sustained an intraoperative left ureteric injury, which was recognized and managed robotically during the same session via direct ureteroureterostomy.

There were no major (Clavien-Dindo Grade III–V) complications, reoperations, conversions, or ICU admissions. All 12 patients (100%) were mobilized on postoperative day one. The mean length of hospital stay was 3.7 ± 2.8 days, with a median of 2 days (range 1–11). The mean time to first flatus was 1.7 ± 0.6 days [median 2, range 1–2], and the mean time to first oral intake was 1.9 ± 0.5 days [median 2, range 1–3].

There were no 90-day readmissions or deaths.

Table 2. Surgical procedures and operative details.

No.	Robotic-assisted emergency procedure	OT (h)	Drain	Conversion
1	Transverse colectomy	3	No	No
2	Anterior resection	3	No	No
3	Right colectomy, sigmoidectomy, extensive adhesiolysis, and resection of recurrent liposarcoma tumours	6	Yes	No
4	Anterior resection	4	Yes	No
5	Anterior resection	4	No	No
6	Ureteric injury repair	3	Yes	No
7	Hernia repair *(TAPP)*	2	No	No
8	Right hemicolectomy	3	Yes	No
9	Anterior resection and ileostomy	4	Yes	No
10	Right hemicolectomy and ileostomy	4	No	No
11	Hernia repair *(TAPP)*	2	No	No

h = hours; OT = operative time.

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Table 3. Complications, management, and ICU requirement.

ID	ICU	Complications	Clavien-Dindo grade	Management
1	No	None	—	—
2	No	None	—	—
3	No	SSI	I	Antibiotics *(cefuroxime, metronidazole)*
4	No	None	—	—
5	No	None	—	—
6	No	None	—	—
7	No	None	—	—
8	No	None	—	—
9	No	None	I	-
10	No	None	—	—
11	No	None	—	—

ICU = intensive care unit; SSI = surgical site infection.

Table 4. Postoperative data and outcomes.

ID	Time to first flatus (d)	Time to mobilization (d)	Time to first oral feeding (d)	LOS (d)	90-day mortality	90-day readmission
1	1	1	1	2	No	No
2	2	1	2	2	No	No
3	2	1	2	11	No	No
4	2	1	2	2	No	No
5	2	1	2	2	No	No
6	2	1	2	11	No	No
7	1	1	1	1	No	No
8	2	1	2	4	No	No
9	3	1	3	6	No	No
10	1	1	2	2	No	No
11	1	1	2	2	No	No

d = days; LOS = length of stay.

4. Discussion

Open surgery has long been the standard approach for emergency general surgery, particularly in critically ill patients, due to its speed, familiarity, and the ability to handle complex or unstable anatomy [Cirocchi 2017]. However, it is associated with increased tissue trauma, higher complication rates—including surgical site infections (SSIs)—and prolonged recovery and hospitalization [Mohiuddin 2013].

Laparoscopic surgery sought to overcome these drawbacks, offering reduced postoperative pain, faster recovery, and shorter hospital stays [Jaschinski 2018]. Yet, in emergency situations, it presents technical challenges, particularly in patients with dense adhesions, large tumors, or distorted anatomy [Chandio 2009].

Robotic-assisted surgery, as demonstrated in our study, presents a promising alternative. Operative times were comparable to those reported for open and laparoscopic approaches for equivalent procedures, such as colectomies and anterior resections [Huang 2020; Kim 2024]. The absence of conversion in our series further supports the feasibility and safety of robotic surgery in emergency scenarios, even in technically demanding cases.

This reliability is contingent on surgical expertise. Our outcomes support the World Society of Emergency Surgery (WSES) recommendation that robotic surgery can be appropriate in emergencies when performed by trained teams [de'Angelis 2022]. The predictability of our results underlines the importance of experience, not only in robotic technique but also in intraoperative decision-making.

Conversions remain a concern in minimally invasive surgery, often resulting in worse outcomes than primary open surgery [Shah 2022]. Robotic platforms, with their improved dexterity and visualization, appear to reduce the likelihood of conversion compared to laparoscopy [Shah 2022], which aligns with our experience.

However, safe and effective use of robotic surgery in emergencies is not simply a matter of platform access. It requires formal training—ideally through dedicated fellowships—and significant prior experience in elective robotic cases [Panteleimonitis 2016]. Just as crucial is the presence of a skilled, adaptable surgical team capable of anticipating and managing intraoperative challenges [Schuessler 2020].

In our study, complication rates were low, with no major adverse events or conversions, and all patients were mobilized on the first postoperative day. The absence of 90-day readmissions or mortality further supports the potential of robotic surgery to deliver favorable outcomes in emergency care, even among older, comorbid patients.

All cases were included based on clinical urgency and indication, and final eligibility for a robotic approach was determined by the attending surgeon, ensuring appropriate patient selection.

This study is not without limitations. The small sample size and single-center design limit the generalizability of our findings, and outcomes achieved by an experienced robotic team may not be replicable in lower-volume institutions or settings without dedicated robotic training. The lack of a comparator group also limits direct comparisons with conventional emergency approaches. Nevertheless, to our knowledge, this is one of the very few prospective clinical series evaluating the feasibility and outcomes of robotic-assisted surgery in unselected emergency general surgical cases. These preliminary findings provide real-world evidence of the potential role of robotic platforms in acute care surgery. Further prospective, multicenter studies are warranted to validate these results and support the development of structured protocols for the safe implementation of robotic-assisted techniques in emergency surgical practice.

5. Conclusions

Robotic-assisted surgery is a feasible, safe, and effective option for selected emergency general surgical procedures when performed by an experienced surgeon and a dedicated team. In this prospective series, no conversions, major complications, readmissions, or mortality were observed, and postoperative recovery was favorable. These results support the emerging role of robotic platforms in emergency settings, particularly when institutional expertise and infrastructure are in place. While further large-scale studies are needed, our findings contribute to the growing body of evidence supporting the integration of robotics into acute care surgery.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The dataset supporting the results of this study is available within the manuscript itself; all relevant data are included in the tables and main text.

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