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INTEGRATED RADIOLOGY, ANESTHESIA, LABORATORY, AND SURGICAL PATHWAYS FOR EMERGENCY ABDOMINAL SURGERY: EFFECTS ON TIME TO INTERVENTION AND COMPLICATIONS; A SYSTEMATIC REVIEW

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Abstract

Background: Delays in emergency abdominal surgery increase complications and mortality. Hospitals have introduced integrated pathways linking radiology, laboratory testing, anesthesia, and operating room access to improve timeliness and outcomes. **Objective:** To synthesize evidence on integrated emergency abdominal surgery pathways and their associations with time to intervention and postoperative complications. **Methods:** We conducted a systematic review following PRISMA. PubMed Central was searched for full-text studies evaluating integrated or pathway-based models for emergency abdominal surgery (emergency laparotomy bundles, acute care surgery services, ERAS-type emergency pathways, and diagnostic, surgical pathways such as appendicitis pathways). Eligible designs included randomized trials, prospective audits, and cohort studies reporting timeliness outcomes and, or clinical outcomes. **Results:** Eleven original studies were included. Bundle-based emergency laparotomy pathways were associated with lower risk-adjusted 30-day mortality in multicenter quality improvement work and improved longer-term outcomes in standardized management programs. Acute care surgery models and organizational pathways that included dedicated emergency resources were consistently linked to shorter delays and improved efficiency metrics. Several studies reported reductions in postoperative complications and, or length of stay after pathway implementation. **Conclusion:** Integrated pathways that coordinate radiology, laboratory workflows, anesthesia readiness, and surgical access are associated with improved timeliness, and many studies report fewer complications and, or lower mortality. Heterogeneity in pathway components and outcome definitions limits pooling; future multicenter studies should standardize timeliness metrics and complication reporting.

Keywords: Emergency Abdominal Surgery; Emergency Laparotomy; Care Bundle; Acute Care Surgery; Clinical Pathway; Time To Operation; Complications; PRISMA.

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INTRODUCTION

Emergency abdominal surgery, particularly emergency laparotomy, is a high-risk clinical scenario with substantial variation in processes and outcomes in hospitals (Huddart et al. 2014; Stephens et al. 2019). Timeliness matters: delays in diagnosis and transfer to the operating room are repeatedly emphasized as targets for quality improvement, and large initiatives have been developed to standardize care and reduce unwarranted variation (Stephens et al. 2019; Ilyas et al. 2019).

A central challenge is that time to intervention depends on multiple departments working as one system. Radiology capacity affects time-to-CT for suspected intra-abdominal catastrophe; laboratory turnaround times influence sepsis recognition, resuscitation, transfusion planning, and perioperative optimization; anesthesia availability influences decision-to-incision; and operating-room access determines whether “emergency” truly means immediate. These realities help explain why pathways increasingly take a whole-hospital approach rather than focusing on a single surgical step (Peden et al. 2021; Stephens et al. 2019).

Risk stratification tools are often embedded in pathways to trigger escalation, consultant review, early antibiotics, goal-directed fluids, and postoperative critical care (Nag et al. 2015; Alabbasy et al. 2023). Frailty is another pathway-relevant domain because it predicts adverse outcomes and influences decisions about escalation, monitoring intensity, and postoperative location of care (Park et al. 2024; Tian et al. 2023).

In parallel, system-level redesign has accelerated globally through the acute care surgery (ACS) model, which formalizes emergency surgical decision-making, OR access, and multidisciplinary coordination (van der Wee et al. 2020; Ilyas et al. 2019). Consensus guidance also supports ERAS-type principles adapted for emergency laparotomy (early antibiotics, resuscitation, early senior decision-making, standardized anesthesia, analgesia, and defined postoperative pathways) while acknowledging the need to tailor to time-critical emergency settings (Peden et al. 2021).

Aim: This systematic review evaluates whether integrated radiology–laboratory–anesthesia–surgery pathways in emergency abdominal surgery are associated with faster time to intervention and reduced postoperative complications, and it summarizes which pathway components are most consistently linked to benefit.

METHODS

Design: Systematic review conducted according to PRISMA 2020.

Eligibility criteria: we include adolescents, adults (or mixed populations) undergoing emergency abdominal surgery (including emergency laparotomy and high-acuity emergency general surgery); undergone integrated pathways, bundles, or service models explicitly designed to coordinate ≥2 of the following domains: radiology, imaging, laboratory, resuscitation protocols, anesthesia, perioperative planning, and surgical access (dedicated emergency OR, team); in usual care, pre-implementation period, or alternative organizational pathway.

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Outcomes: Timeliness (time to imaging, decision-to-incision, delay frequency, OR waiting time), complications (overall or major complications), mortality, length of stay, ICU admission, costs where available.

Study designs: Randomized trials, prospective audits, and observational cohort studies (pre, post, interrupted time series, multicenter cohorts).

Setting: Hospital, ED, surgical services.

Source restriction: PMC full-text articles only.

Information sources and search strategy: We searched PubMed and PubMed Central for full-text articles using combinations of: *emergency laparotomy*, *emergency abdominal surgery*, *care bundle*, *pathway*, *acute care surgery*, *ERAS emergency*, *dedicated emergency theatre*, *time to operation*, *delay*, and *complications*. We also screened reference lists of included full-text articles to identify additional eligible PMC studies.

Study selection: Two stage screening (title, abstract then full text). Disagreements resolved by discussion. A PRISMA flow was recorded. **Data extraction:** We extracted study design, country, setting, pathway components (radiology, lab, resuscitation, anesthesia, OR access), sample size, comparator, and outcomes (timeliness, complications, mortality, LOS, costs). Where reported, we extracted adjusted estimates.

Risk of bias: Because included studies were heterogeneous and mostly nonrandomized pre, post designs, we assessed methodological limitations qualitatively (confounding, secular trends, selection bias, outcome measurement consistency).

Synthesis: Narrative synthesis with structured tables. Meta-analysis was not performed due to heterogeneity of interventions and outcome definitions.

RESULTS

Study Selection and Characteristics

Eleven original PMC studies met inclusion criteria: quality-improvement emergency laparotomy bundles (Huddart et al. 2014; Doyle et al. 2019), bundle care in major abdominal emergency surgery (Trangbæk et al. 2022), standardized emergency laparotomy management (Timan et al. 2024), transdisciplinary emergency laparotomy pathway implementation (Ong et al. 2021), ACS, EGS system models including Korea and pandemic restructuring (Yi et al. 2024; Mathur et al. 2020), emergency general surgery service redesign using “marginal gains” (Panagiotopoulou et al. 2019), an appendicitis diagnostic, surgical pathway improving time to CT and intervention (Ball et al. 2014), and an ERAS protocol trial in emergency laparotomy-type populations (Sharma et al. 2021).

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Table 1: Characteristics of included original studies

Study	Country, setting	Design	Population	Pathway components (radiology, lab, anesthesia, OR)	Comparator	Key outcomes reported
Huddart et al. 2014	UK, multicenter	QI pre, post	Emergency laparotomy	Early warning, antibiotics; decision-to-op target (<6h); goal-directed fluids; ICU escalation	Pre-bundle care	30-day mortality, process compliance
Doyle et al. 2019	Multicenter	Cohort (bundle evaluation)	Emergency laparotomy	Bundle implementation in sites; periop optimization elements	Pre-bundle	AKI incidence; survival signals; processes
Trangbæk et al. 2022	Denmark, single center	Cohort (bundle implementation)	Major abdominal emergency surgery	Perioperative bundle care	Pre-implementation	30 day mortality; long-term mortality; CCI
Timan et al. 2024	Sweden	Prospective intervention	Emergency laparotomy	Standardized perioperative management protocol	Control cohort	90-day and 1-year mortality; LOS
Ong et al. 2021	Singapore, regional hospital	Audit pre, post	Emergency laparotomy	Transdisciplinary pathway (ED, surgery, geriatrics, anesthesia, nursing, allied health)	Pre-pathway	Complications; mortality; efficiency; costs
Yi et al. 2024	South Korea, multicenter	Retrospective cohort	Emergency general surgery	ACS system implementation (EGS structure)	Pre-ACS	Clinical outcomes; system performance
Mathur et al. 2020	Australia	Pre, post service model	EGS, trauma under COVID reorg	Enhanced ACS teams; separation of teams; efficiency redesign	Previous ACS model	Efficiency, outcomes, costs
Panagiotopoulou et al. 2019	UK high-volume center	Service redesign study	EGS admissions	Ambulatory clinic; urgent GI list; senior decision-making; pathway redesign	Baseline service	Process, efficiency; admissions; breaches
Ball et al. 2014	Canada	Clinical pathway study	Suspected appendicitis	Coordinated ED-radiology-surgery pathway	Usual care	Time to CT; time to surgery
Sharma et al. 2021	India	Randomized trial	Emergency abdominal surgery (incl. perforation, obstruction)	ERAS protocol (periop standardization)	Conventional care	LOS; morbidity indicators

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Table 2: Main findings focused on time to intervention and complications

Study	Timeliness findings	Complications, mortality findings
Huddart et al. 2014	Bundle included a decision-to-operation target (<6h) and ICU escalation (Huddart et al. 2014).	Risk-adjusted 30-day mortality decreased from 15.6% to 9.6% after ELPQuiC implementation (Huddart et al. 2014).
Doyle et al. 2019	Process adoption increased but timeliness endpoints were not the primary focus (Doyle et al. 2019).	AKI incidence was not reduced after bundle implementation in this analysis (Doyle et al. 2019).
Trangbæk et al. 2022	Pathway emphasized standardized perioperative bundle delivery (Trangbæk et al. 2022).	30-day mortality decreased after bundle care; long-term difference persisted but was not significant at 1 year; CCI change not significant (Trangbæk et al. 2022).
Timan et al. 2024	Standardized management protocol targeted system-level delivery (Timan et al. 2024).	90-day mortality 14.1% vs 20.8%; adjusted 1-year mortality 19.7% vs 27.8% (intervention vs control) (Timan et al. 2024).
Ong et al. 2021	Transdisciplinary pathway coordinated ED–anesthesia–surgery workflows (Ong et al. 2021).	Associated with reduced postoperative complications and improved efficiency outcomes (Ong et al. 2021).
Yi et al. 2024	ACS system intended to speed judgment and emergency operative care (Yi et al. 2024).	Evaluated improvements in outcomes after ACS implementation (Yi et al. 2024).
Mathur et al. 2020	Reorganized ACS service improved efficiency metrics during COVID response (Mathur et al. 2020).	Reported improved clinical outcomes and reduced costs compared with previous model (Mathur et al. 2020).
Panagiotopoulou et al. 2019	Service redesign aimed to expedite senior decisions and reduce breaches, admissions (Panagiotopoulou et al. 2019).	Demonstrated operational improvements through service restructuring (Panagiotopoulou et al. 2019).
Ball et al. 2014	Pathway decreased times to CT and to surgical intervention (Ball et al. 2014).	Focused on timeliness; downstream outcomes variably reported (Ball et al. 2014).
Sharma et al. 2021	ERAS pathway standardized perioperative workflow.	Shorter LOS and fewer morbidities vs conventional care were reported (Sharma et al. 2021).

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In emergency laparotomy-focused bundle studies, integrated pathways most consistently targeted: early recognition, early antibiotics, resuscitation (lab-guided), time-bound progression to OR (anesthesia + theatre readiness), and planned ICU admission for high-risk patients (Huddart et al. 2014; Trangbæk et al. 2022). Standardized emergency laparotomy management showed significant reductions in 90-day and 1-year mortality compared with controls (Timan et al. 2024). Transdisciplinary models integrating ED physicians, surgeons, anesthetists, nursing and allied health were associated with fewer postoperative complications and improved efficiency outcomes (Ong et al. 2021). Radiology-linked pathways (suspected appendicitis pathway) demonstrated improved time to CT and earlier surgical intervention (Ball et al. 2014).

DISCUSSION

This review supports the concept that emergency abdominal surgery outcomes are strongly influenced by system performance, not only surgeon skill. Large variations in emergency laparotomy care and outcomes have motivated structured quality improvement and bundled approaches (Stephens et al. 2019; Huddart et al. 2014). Our findings align with the idea that pathways work best when they coordinate multiple bottlenecks simultaneously, radiology access, laboratory-guided resuscitation, anesthesia readiness, and operating-room availability, rather than optimizing one step in isolation (Peden et al. 2021; Ilyas et al. 2019). Organizational studies show that delays to emergency surgery are common and vary by hospital pathway design; pathways that include dedicated emergency theatres, teams are associated with fewer delays (Lepercq et al. 2023). This complements clinical pathway evidence where targeted redesign reduced time to key milestones, such as time to CT and time to surgery in suspected appendicitis (Ball et al. 2014). Because time-to-intervention is multi-determinant, successful models often formalize governance (who leads), escalation triggers (risk scores, frailty), and resource access (OR, ICU) (Nag et al. 2015; Alabbasy et al. 2023).

The most compelling mortality improvement signal in this evidence base comes from emergency laparotomy bundle implementation and standardized perioperative management programs (Huddart et al. 2014; Timan et al. 2024). However, not all outcomes move in the same direction in all studies. For example, while bundles may improve survival and process adherence, specific complications such as AKI may not decline without additional kidney-protective strategies or more granular hemodynamic management (Doyle et al. 2019). This underlines that “integrated pathway” is not a single intervention; pathway content and fidelity matter. Frailty is particularly relevant in emergency laparotomy populations and is recommended, used to guide escalation and postoperative planning (Park et al. 2024; Tian et al. 2023). Similarly, risk models and scoring systems help identify high-risk patients who benefit from early ICU planning, senior decision-making, and time-critical OR access (Nag et al. 2015; Alabbasy et al. 2023). From a pathway engineering perspective, these tools convert clinical risk into operational triggers. ACS service models provide structural capacity for 24, 7 emergency decision-making and multidisciplinary throughput, which can enable consistent pathway delivery (van der Wee et al. 2020; Yi et al. 2024). During the pandemic, rapid restructuring

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of ACS services was reported to improve efficiency and outcomes while maintaining workforce separation, emphasizing the adaptability of integrated models (Mathur et al. 2020). Economic evaluation suggests that implementing emergency laparotomy bundles can be cost-effective from a societal perspective even if in-hospital costs rise, reinforcing the rationale for system investment (Ebm et al. 2018). Most evidence is observational (pre, post or cohort) with risk of confounding and secular trend bias; pathway components differ widely, and reporting of “time to intervention” is inconsistent. Heterogeneity limited quantitative pooling. Finally, some studies focus on service redesign outcomes rather than standardized complication definitions, complicating cross-study comparison.

CONCLUSION

Integrated pathways that coordinate radiology, laboratory-guided resuscitation, anesthesia readiness, and emergency surgical access are associated with improved timeliness and, in many studies, fewer complications and, or lower mortality after emergency abdominal surgery. The strongest signals come from emergency laparotomy care bundles and standardized management protocols, while ACS service models appear to provide enabling infrastructure for consistent pathway delivery. Evidence remains heterogeneous and largely nonrandomized; future multicenter studies should adopt standardized definitions for surgical delay, decision-to-incision intervals, and complication reporting, and should measure pathway fidelity to clarify which components drive benefit.

List of abbreviations

ACS: Acute Care Surgery

AKI: Acute Kidney Injury

CCI: Comprehensive Complication Index

CT: Computed Tomography

ED: Emergency Department

EGS: Emergency General Surgery

EL: Emergency Laparotomy

ELAP: Emergency Laparotomy Pathway

ELPQuiC: Emergency Laparotomy Pathway Quality Improvement Care

ERAS: Enhanced Recovery after Surgery

ICU: Intensive Care Unit

LOS: Length of Stay

NELA: National Emergency Laparotomy Audit

P-POSSUM: Portsmouth Physiological and Operative Severity Score for the Enumeration of Mortality and Morbidity

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

QI: Quality Improvement

OR: Operating Room

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