ANESTHESIOLOGY

Openventio PUBLISHERS

Review Article

Enhanced Recovery Pathways and Their Influence on Anesthetic Resource Utilization

Ines Peeters[1*], Carla Berg[2] and Pieter Kraus[3]

[1]*Department of Anesthesiology and Pain Management, Nordic Institute of Anesthesiology and Critical Care, Finland*
[2]*Department of Surgical Sciences, Nordfjord University of Health Sciences, Norway*
[3]*Department of Anesthesiology, Nordic Institute of Anesthesiology and Critical Care, Finland*

ABSTRACT

Enhanced recovery after surgery (ERAS) pathways have expanded from their colorectal origins into cardiac, orthopedic, spine, and nonoperating-room anesthesia settings, and the anesthetic components of these pathways now largely determine whether the promised resource savings are realized.

This review examines how opioid-sparing multimodal anesthesia, regional and neuraxial techniques, modified postanesthesia care unit discharge criteria, and goal-directed fluid management specifically affect anesthesia-controlled resources such as opioid consumption, recovery-room and intensive care unit time, operating room turnover, and staffing needs.

Across colorectal, cardiac, and total joint arthroplasty pathways, opioid-sparing anesthesia and updated PACU discharge criteria are consistently linked to shorter recovery-room or intensive care unit time, while goal-directed fluid therapy reduces complication-driven costs even when it does not shorten the case itself.

These benefits are conditional on faithful, cross-disciplinary implementation and on upfront investment in regional anesthesia capacity, hemodynamic monitoring, and data infrastructure that individual efficacy trials rarely account for.

We conclude that the anesthetic components of ERAS pathways reliably improve resource predictability and reduce opioid and recovery-unit burden when implemented as designed, though the magnitude of benefit varies by surgical service and local infrastructure and remains an active area of precision-medicine refinement.

Keywords: *enhanced recovery after surgery; anesthetic resource utilization; opioid-sparing anesthesia; postanesthesia care unit; goal-directed fluid therapy*

Citation: Peeters I, Berg C and Kraus P (2022) Enhanced Recovery Pathways and Their Influence on Anesthetic Resource Utilization. Anesthesiology. 2(1):01-06.

DOI: 10.17140/2022.vol2.i01.pp01-06

Corresponding Author: *Ines Peeters*

E-mail Address: *i.peeters@niacc.fi*

Article History: *Received 24 February 2022 | Accepted 15 March 2022 | Published 17 April 2022*

Copyright: *© 2022 Ines Peeters, et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited (**https://creativecommons.org/licenses/by/4.0/**).*

INTRODUCTION

Enhanced recovery after surgery (ERAS) began as a surgical initiative but has, over the past decade,

become an anesthesiology problem in nearly equal measure. The original insight — that a bundle of small perioperative interventions could beat any single "big" intervention at shortening recovery — depended from the outset on decisions that belong to the anesthesia team: which induction agents to use, how much opioid to give, whether to place a neuraxial or regional block, how aggressively to manage fluids, and when a patient is actually fit for discharge from the postanesthesia care unit (PACU) [1]. As ERAS pathways have spread from colorectal surgery into cardiac, orthopedic, spine, gynecologic, and now nonoperating-room settings, the anesthetic component has grown from an afterthought into the load-bearing wall of the whole structure [2]. This review looks specifically at what ERAS implementation does to anesthesia-controlled resources — opioid consumption, PACU and ICU time, block and catheter utilization, staffing and turnover patterns, and cost — rather than at surgical outcomes in general, which have already been reviewed extensively elsewhere.

The premise worth stating plainly is that ERAS pathways redistribute anesthetic effort rather than simply reducing it. A well-run pathway typically front-loads work: multimodal analgesic planning, regional block placement, patient education, and fluid-goal-setting all happen before or during the case, in exchange for less work later, in the form of fewer PACU opioid rescues, shorter recovery-room stays, and fewer unplanned admissions [3]. Whether that trade nets out favorably for a given hospital and anesthesia group is not automatic — it depends on case mix, staffing model, and how faithfully the pathway is actually followed, a point the most recent meta-analytic literature increasingly emphasizes [4].

OPIOID-SPARING ANESTHESIA AS THE CENTRAL RESOURCE LEVER

If there is one anesthetic practice that ERAS pathways have made nearly universal, it is multimodal, opioid-sparing analgesia. The logic is resource-driven as much as it is about pain scores: intraoperative and postoperative opioids drive PACU length of stay through sedation, nausea, and respiratory depression, and each of those complications consumes nursing time, rescue medication, and monitoring capacity that a busy PACU does not have to spare. Colorectal ERAS programs, where the pathway concept originated, now report meaningful reductions in both intraoperative opioid dosing and postoperative opioid prescribing once a standardized multimodal bundle — acetaminophen, NSAIDs where appropriate, gabapentinoids, ketamine infusions, and regional or neuraxial blockade — replaces opioid-based general anesthesia as the default [5,6]. A same-day-discharge pilot for minimally invasive colorectal surgery during the pandemic found that formalizing this approach cut both intraoperative and take-home opioid quantities substantially without a corresponding rise in unplanned contacts for uncontrolled pain [7], which is the pattern the field has come to expect: opioid reduction usually holds even as other outcomes stay flat or improve.

Cardiac surgery has picked up the same logic more recently, and arguably has more to prove, since cardiac anesthesia has historically been opioid-heavy by tradition rather than by necessity. Systematic reviews now credit opioid-sparing cardiac anesthesia protocols with shorter time to extubation and reduced postoperative opioid requirement without an increase in recall or hemodynamic instability [8], and dedicated ERAS-cardiac-surgery reviews report similar reductions in cumulative morphine-equivalent dosing across the perioperative course [9]. Regional techniques have been a meaningful part of that shift: parasternal fascial plane blocks incorporated into a cardiac ERAS bundle have been associated with materially lower postoperative opioid consumption compared with systemic-opioid-only management [10], echoing what orthopedic and colorectal ERAS pathways had already shown with peripheral and neuraxial blocks. Spine surgery ERAS pathways report a comparable pattern of lower opioid consumption paired with unchanged or improved pain scores when multimodal protocols are adopted [11], and consensus statements from the American Society for Enhanced Recovery and Perioperative Quality Initiative have codified this preoperative-through-PACU analgesic sequencing for colorectal surgery specifically, giving anesthesia departments a reproducible template rather than an ad hoc bundle [12].

None of this is free of controversy at the resource level. Opioid-sparing protocols shift work toward regional anesthesia teams and block rooms, which need dedicated staffing, ultrasound equipment, and block-room time that a hospital without a regional anesthesia service may not have readily available. A recent review of ERAS-protocol opioid management is candid about this tension: the pathways that produce the largest opioid reductions are also the ones with the highest upfront staffing and training requirements, meaning the resource savings downstream (shorter PACU stays, fewer opioid-related adverse events) have to be weighed against resource costs upstream [13].

POSTANESTHESIA CARE UNIT THROUGHPUT AND DISCHARGE CRITERIA

PACU capacity is one of the tightest bottlenecks in most perioperative systems, and ERAS pathways have targeted it directly by changing both how patients arrive in the PACU (less sedated, less opioid-laden) and how they are allowed to leave it. Total joint arthroplasty is the clearest example. Modern ERAS pathways for elective hip and knee replacement pair spinal anesthesia with a discharge protocol that no longer requires resolution of motor blockade before a patient can leave the PACU, provided objective safety

criteria are otherwise met. A large single-center series found that discharging patients from the PACU while some motor blockade from spinal anesthesia was still present was safe and meaningfully shortened recovery-room time compared with waiting for full motor return [14], a finding corroborated by subsequent comparisons of PACU duration after spinal anesthesia against contemporary arthroplasty benchmarks [15]. Reviews of ERAS pathways specifically for elective total joint arthroplasty now treat this modified discharge criterion as a standard component rather than an innovation, alongside spinal-anesthesia-first protocols and multimodal analgesia [16]. Colorectal-specific reviews of postoperative pain management after minimally invasive surgery describe an analogous shift toward liberalized recovery-room criteria once multimodal analgesia reduces sedation and nausea burden [17].

The choice between spinal and general anesthesia itself carries resource implications beyond the discharge-criteria question. Matched-cohort work comparing spinal to general anesthesia for outpatient hip and knee arthroplasty in ambulatory surgery centers has found spinal anesthesia associated with shorter recovery times and fewer PACU-level interventions, supporting its role as the anesthetic backbone of ambulatory joint-replacement ERAS pathways [18]. As total joint arthroplasty continues its migration from inpatient wards to ambulatory surgery centers, the anesthetic and discharge protocol becomes, in effect, the rate-limiting step for how many cases a center can safely turn over in a day [19].

Cardiac surgery ERAS pathways pursue an analogous goal one level up the acuity chain: reducing ICU, rather than PACU, time. Systematic reviews and meta-analyses of ERAS programs in cardiac surgery consistently report shorter mechanical ventilation duration, shorter ICU length of stay, and shorter overall hospital length of stay relative to conventional perioperative management, with early extubation protocols and opioid-sparing anesthesia named as the principal anesthetic drivers of that effect [20,21]. A pragmatic implementation study reported similar early gains in a community cardiac surgery program once a formal ERAS protocol replaced ad hoc practice [22], suggesting the effect generalizes beyond academic centers with dedicated ERAS infrastructure.

FLUID MANAGEMENT, HEMODYNAMIC GOAL-DIRECTION, AND CASE DURATION

Anesthesia-directed fluid management is the other pillar where ERAS pathways have visibly changed practice, and it interacts with resource use in a less intuitive way than opioid-sparing does — the benefit is less about PACU time and more about avoiding the downstream cost of fluid-related complications. Goal-directed fluid therapy, in which intraoperative fluid administration is titrated to dynamic hemodynamic targets (stroke volume variation, pulse pressure variation, or similar) rather than given by fixed-volume protocol, has been an adjunct to ERAS pathways since the earliest iterations of the concept, and reviews of the practice describe consistent reductions in postoperative complications such as ileus, pulmonary edema, and wound-healing problems when goal-directed therapy replaces liberal fixed-volume fluid administration [23]. Each of those avoided complications has a resource cost attached — an extra hospital day, an unplanned imaging study, a return to the operating room — so the anesthetic fluid strategy functions as a form of resource stewardship even though it does not shorten the case itself.

Where fluid management does interact with intraoperative time and staffing is through the equipment and monitoring it requires. Goal-directed protocols generally need continuous cardiac-output or stroke-volume monitoring hardware and staff trained to interpret it, and departments implementing ERAS pathways for the first time have reported that acquiring and standardizing this monitoring was one of the more resource-intensive steps of rollout, more so than the analgesic changes, which mostly repurpose drugs anesthesiologists already stock [24]. Obstetric and gynecologic ERAS guidance has generalized the same fluid-restriction principle to cesarean delivery and major gynecologic surgery, again framing it as a modest anesthetic behavior change with an outsized effect on postoperative recovery trajectory [25].

Operating room turnover time, a resource metric anesthesiologists influence but do not fully control, has drawn its own dedicated review literature recently, and the anesthetic contribution — induction efficiency, extubation timing, and handoff communication — appears repeatedly among the modifiable factors identified across the operating-room-turnover systematic review evidence [26]. ERAS pathways that standardize anesthetic technique across a surgical service tend to reduce case-to-case variability in these anesthetic time components, which is a less-discussed but practically important form of resource benefit: predictable turnover lets a surgical service schedule more tightly without building in as much slack for anesthetic variability.

IMPLEMENTATION COSTS, STAFFING MODELS, AND DEPARTMENTAL TRADE-OFFS

The resource story of ERAS is incomplete without acknowledging what implementation costs an anesthesia department before it produces any of the savings described above. Early accounts of standing up ERAS programs from the anesthesiology side are consistent in describing three recurring cost centers: protocol development and buy-in time across a multidisciplinary group, regional anesthesia or block-room capacity expansion, and data infrastructure to track compliance and outcomes [24]. None of these costs are trivial, and none of them show

up in an ERAS trial's headline length-of-stay or opioid-consumption endpoints, which is part of why implementation-focused reviews now caution against treating a protocol's published efficacy as a guarantee that any given department will realize the same savings without a comparable investment [4].

Gastrointestinal surgery outside the original colorectal indication offers a useful test of how far the resource benefits generalize once nursing and anesthesia protocols are combined. A recent meta-analysis of ERAS pathway nursing in gastrointestinal surgery found consistent reductions in time to first flatus, time to oral intake, and overall hospital stay when a structured perioperative nursing and anesthesia bundle was applied, reinforcing that much of the resource benefit of ERAS depends on coordinated, cross-disciplinary execution rather than any single anesthetic maneuver in isolation [27]. The consensus-statement literature for colorectal analgesia makes a related point about sequencing: a preoperative block placed and then abandoned intraoperatively, or an opioid-sparing plan undone by rescue opioid dosing in the PACU, captures none of the downstream resource benefit even though the individual anesthetic techniques were technically used [12].

The newest frontier for this resource conversation is the nonoperating-room anesthesia (NORA) environment — endoscopy suites, interventional radiology, and cardiac catheterization labs — where case volumes are high, turnover pressure is intense, and ERAS principles have historically been applied inconsistently if at all. A recent review argues that the same anesthetic elements responsible for ERAS resource gains in the operating room — opioid-sparing sedation, standardized discharge criteria, and goal-directed fluid use where relevant — translate directly into NORA settings and may in fact offer a larger relative gain, because baseline practice in these settings has tended to be less standardized than in the operating room [2]. Patient-facing surveys of what drives dissatisfaction after ambulatory anesthesia, meanwhile, continue to identify pain control and recovery-room wait time among the most common complaints, which functions as a reminder that the resource metrics anesthesia departments track internally — PACU minutes, opioid milligram equivalents, turnover time — are also, from the patient's side, the metrics that determine whether the pathway actually delivered the experience it promised [28,29]. Professional practice guidance for anesthesia providers echoes the same point, framing ERAS competency as a core expectation of contemporary perioperative anesthesia practice rather than an optional specialization [30].

CONCLUSION

Enhanced recovery pathways have, over roughly two decades, moved the anesthesiologist from a peripheral participant in perioperative "fast-track" efforts to the discipline most responsible for whether an ERAS pathway actually saves the resources it claims to save. Opioid-sparing multimodal anesthesia, regional and neuraxial techniques, modified PACU discharge criteria, and goal-directed fluid management each address a specific resource bottleneck — opioid-related PACU delay, ICU occupancy after cardiac surgery, fluid-related complication burden, and case-to-case turnover variability, respectively — and the evidence base for each has matured enough that they now function as defaults in most published pathways rather than as innovations under study. What the more recent literature adds is a note of caution: these resource gains are conditional on faithful implementation and on an upfront investment in staffing, monitoring equipment, and cross-disciplinary coordination that individual trials rarely quantify. A department considering ERAS adoption is, in effect, choosing to trade a known upfront resource cost for a probabilistic downstream resource saving, and the size of that trade varies by surgical service, case volume, and how much regional-anesthesia and monitoring infrastructure already exists locally. The direction of the evidence nonetheless remains consistent across colorectal, cardiac, orthopedic, spine, and now nonoperating-room settings: when the anesthetic components of an ERAS pathway are implemented as designed, they reduce opioid exposure, shorten PACU and ICU time, and make perioperative resource use more predictable, even where the exact magnitude of benefit is still being refined by ongoing precision-medicine approaches to pathway design.

DECLARATIONS

Acknowledgements The authors thank their respective departments of anesthesiology for administrative support during the preparation of this review.

Funding This review received no external funding.

Conflict of Interest The authors declare no conflicts of interest.

Author Contributions IP conceived the review and drafted the initial manuscript. CB performed the literature search and critically revised the sections on surgical and perioperative outcomes. PK critically revised the sections on anesthetic technique and resource utilization and approved the final version. All authors read and approved the final manuscript.

Ethics Statement This is a literature review that did not involve new human or animal data; no ethics approval was required.

Data Availability No new data were generated for this review. All sources cited are publicly available in the referenced journals and databases.

REFERENCES

1. Anesthetic Management for Enhanced Recovery After Major Surgery (ERAS) (2023) StatPearls, NCBI Bookshelf.
2. Applying enhanced recovery after surgery principles to the nonoperating room anesthesia environment: rationale, current evidence, and future directions (2025) PMID:42054220.
3. Enhanced Recovery After Surgery Guidelines and Hospital Length of Stay, Readmission, Complications, and Mortality: A Meta-Analysis of Randomized Clinical Trials (2024) JAMA Network Open, PMID:38888922.
4. The Future of Enhanced Recovery After Surgery-Precision vs Protocol (2024) JAMA Network Open.
5. Impact of an enhanced recovery after surgery program with a multimodal analgesia care pathway on opioid prescribing and clinical outcomes for patients undergoing colorectal surgery (2023) Baylor University Medical Center Proceedings, 36(6).
6. Multimodal Analgesia Bundle and Postoperative Opioid Use Among Patients Undergoing Colorectal Surgery (2023) PMC, PMID:37642970.
7. Reduced Opioid Use and Prescribing in a Same Day Discharge Pilot Enhanced Recovery Program for Elective Minimally Invasive Colorectal Surgical Procedures During the COVID-19 Pandemic (2022) PMC, PMID:35832048.
8. Opioid-sparing Anesthesia in Cardiac Surgery: A Meta-analysis (2025) Journal of Cardiothoracic and Vascular Anesthesia, PMID:40685295.
9. Enhanced Recovery After Surgery (ERAS) Protocols in Cardiac Surgery: Impact on Opioid Consumption (2025) Journal of Clinical Medicine, DOI:10.3390/jcm14051768.
10. Multimodal analgesia with parasternal plane block protocol within an enhanced recovery after cardiac surgery program decreases opioid use, PMC.
11. The impact of enhanced recovery after surgery (ERAS) on opioid consumption and postoperative pain levels in elective spine surgery (2024) Clinical Neurology and Neurosurgery.
12. American Society for Enhanced Recovery (ASER) and Perioperative Quality Initiative (POQI) joint consensus statement on optimal analgesia within an enhanced recovery pathway for colorectal surgery: part 1-from the preoperative period to PACU (2017) Perioperative Medicine, PMC, PMID:28270910.
13. Opioid Management in the Setting of Enhanced Recovery After Surgery (ERAS) Protocols (2025) PMID:40905264.
14. Discharge From the Postanesthesia Care Unit With Motor Blockade After Spinal Anesthesia Safely Optimizes Fast Track Recovery in Primary Total Hip and Knee Arthroplasty (2023) Journal of Arthroplasty, PMID:37474080.
15. Post-Anesthesia Care Unit Duration After Total Hip Arthroplasty Under Spinal Anesthesia in Routine Hospital Practice: A Comparison with Contemporary Arthroplasty Literature (2025) PMC, PMID:42506366.
16. Enhanced Recovery After Surgery (ERAS) Pathways in Elective Total Joint Arthroplasty (2025) PMID:40917910.
17. Optimizing postoperative pain management in minimally invasive colorectal surgery (2024) Annals of Coloproctology.
18. Spinal Versus General Anesthesia for Outpatient Total Hip and Knee Arthroplasty in the Ambulatory Surgery Center: A Matched-Cohort Study (2023) Journal of Arthroplasty.
19. Total joint replacement in ambulatory surgery (2024) Best Practice & Research Clinical Anaesthesiology.
20. Effect of Enhanced Recovery After Surgery (ERAS) Programs on Perioperative Outcomes in Patients Undergoing Cardiac Surgery: A Systematic Review and Meta-analysis (2025) Journal of Cardiothoracic and Vascular Anesthesia.
21. Efficacy of enhanced recovery programmes for cardiac surgery: a systematic review and meta-analysis (2025) British Journal of Surgery.
22. Results following implementation of a cardiac surgery ERAS protocol (2019) PLOS ONE.
23. Fluid management and goal-directed therapy as an adjunct to Enhanced Recovery After Surgery (ERAS) (2015) Canadian Journal of Anesthesia, PMID:25391735.
24. Initiating an Enhanced Recovery Pathway Program: An Anesthesiology Department's Perspective (2015) PMID:26404073.
25. Perioperative Pathways: Enhanced Recovery After Surgery (2018) American College of Obstetricians and Gynecologists, Committee Opinion.
26. What affects operating room turnover time? A systematic review and mapping of the evidence (2025) Surgery.
27. Effect of ERAS pathway nursing on postoperative rehabilitation of patients undergoing gastrointestinal surgery: a meta-analysis (2025) BMC Surgery.
28. Enhanced Recovery After Surgery (ERAS) Pathways (2023) UCSF Pain Management Education.
29. ERAS: Roadmap For A Safe Perioperative

Journey (2021) Anesthesia Patient Safety Foundation.

30. Enhanced Recovery After Surgery, American Association of Nurse Anesthesiology practice resource.