Current Pain and Headache Reports (2018) 22: 74
https://doi.org/10.1007/s11916-018-0727-z

OTHER PAIN (A KAYE AND N VADIVELU, SECTION EDITORS)

The Evolution of Surgical Enhanced Recovery Pathways: a Review

Amir Elhassan[1] · Ahmed Ahmed[1] · Hamdy Awad[1] · Michelle Humeidan[1] · Viet Nguyen[2] · Elyse M. Cornett[3] · Richard D. Urman[4] · Alan David Kaye[2]

Published online: 31 August 2018

Abstract

Purpose of Review Enhanced recovery pathways are a well-defined perioperative health care program utilizing evidence-based interventions in a protocol-like manner designed to standardize techniques including drug selection and dosing to improve results and to reduce overall costs including facilitating earlier discharge from hospitals after surgery.

Recent Findings A PubMed and World Wide Web search was performed with the following key words: enhanced recovery, surgical enhanced recovery, recovery pathways, and enhanced recovery pathways surgery.

Summary This introduction to enhanced recovery pathways reflects its 20-year history, worldwide appeal, and ever growing presence in our practices. Many clinical teams have not, as of yet, incorporated enhanced recovery pathway principles to their practices and therefore, continued evolution should include increasing outreach and formalized guidelines in the future.

Keywords Enhanced recovery pathways · Surgery · Nutrition · Postoperative care · Preoperative care · Fast track recovery

Introduction

Perioperative value-based care necessitates health outcomes improvement via ensuring patient's safety, satisfaction, and high-quality healthcare services for less expense [1]. Enhanced Recovery After Surgery (ERAS)© is a multidisciplinary perioperative approach that has been developed and adopted over the last 20 years to afford such value-based care [2••]. When implemented in various surgical procedures, ERAS practices have shown rapid recovery, improved postoperative outcomes, and cost reduction [3]. However, compliance difficulties have revealed that great efforts should be employed to attain protocol adherence, which is critical for meaningful clinical short- and long-term benefits of ERAS initiatives [4]. Being a multidisciplinary approach, ERAS implementation requires a coordinator responsible for leading compliance, good communication, and collaboration between perioperative team members [5••]. Lack of cooperative teamwork presents a major barrier to ERAS implementation [6].

This article is part of the Topical Collection on *Other Pain*

✉ Alan David Kaye
alankaye44@hotmail.com

Amir Elhassan
amirozmail@gmail.com

Ahmed Ahmed
ahmed.ahmed@osumc.edu

Hamdy Awad
Hamdy.Elsayed-Awad@osumc.edu

Michelle Humeidan
michelle.humeidan@osumc.edu

Viet Nguyen
vnguy24@lsuhsc.edu

Elyse M. Cornett
ecorne@lsuhsc.edu

Richard D. Urman
rurman@bwh.harvard.edu

[1] Department of Anesthesiology, Ohio State University School of Medicine, Columbus, OH, USA

[2] Departments of Anesthesiology and Pharmacology, LSU Health Science Center, 1542 Tulane Avenue, Suite 659, New Orleans, LA 70112, USA

[3] Department of Anesthesiology, LSU Health Shreveport, Shreveport, LA, USA

[4] Department of Anesthesiology, Perioperative and Pain Medicine, Brigham and Women's Hospital, Boston, MA, USA

ERAS Principles

Causes of delayed discharge and its downstream effects prompted creation of the ERAS approach to eliminate these causes, shorten the length of hospital stay, and save money [7]. In other words, ERAS was introduced to optimize perioperative care practices and improve and speed patient recovery [8]. The key principle of ERAS is implementation of the best available evidence-based perioperative care practices to attenuate surgical stress and provide pain and risk-free surgery. Educating and enrolling patients in decision making, maintenance of appropriate volume status, optimum analgesia, and rapid return of the body's baseline functions, are all common goals that ensure optimum perioperative care and successful implementation of ERAS [9].

ERAS Elements

While the core ERAS principle shapes the goals of ERAS protocol, ERAS elements are the perioperative tools to achieve these goals [9]. ERAS elements have been developed based on the causes of prolonged hospital stays, and modified overtime to fit different types of surgeries [8]. Initially ERAS elements included only a combination of regional analgesia, early postoperative oral intake, and early mobilization [10]. The advancement of surgical techniques and development of new surgical skills added an opportunity of incorporating these new techniques and skills as elements of ERAS. For instance, use of laparoscopy as a minimally invasive approach that allows less traumatic incision and early wound healing, has become a significant element in ERAS protocol [11, 12].

Each ERAS protocol has around 17–23 elements [13••, 14–15]. Some of these elements are common and can be applied for different types of surgeries, while other elements are procedure specific and applied only to certain types of surgeries [15, 16]. The common elements include, but are not limited to, preadmission education and information, preadmission optimization, premedication, optimum fasting, goal-directed fluid therapy, multimodal opioid sparing analgesia, early feeding, and mobilization. All are recommended by ERAS guidelines in different surgical specialties. On the other hand, tracheostomy care is a specific element for head and neck surgeries, weight reduction fits more in bariatric surgeries, and minimally invasive surgical approach is a cornerstone in abdominal surgeries [13, 15–17].

Procedure-Specific ERAS

ERAS practices were first applied to colorectal surgeries. When ERAS showed significant improvements in outcomes in colorectal surgeries, the practices were accepted, modified, and applied by other different specialties. Currently, there are many guidelines for ERAS implementation in different types of surgeries. These guidelines include, but are not limited to, ERAS recommendations for colorectal surgeries, breast reconstruction, liver surgery, pancreaticodudenectomy, head and neck, orthopedics, gynecological, and urological surgery [13–15, 18–21].

History

Initial Studies

In the early 1990s, there were few preliminary clinical studies pursuing rapid postoperative recovery [22, 23]. These studies tried to expedite the perioperative management and enhance the patient recovery after cardiac surgeries to facilitate their quick, yet safe discharge [22, 23]. Engelman et al. studied a small sample of patients undergoing coronary artery bypass grafts (CABG) surgeries, and revealed a reduced length of stay in the intensive care unit (ICU) by 20% with improved postoperative outcomes [22]. The concept at that time was described as "fast track recovery". However, later on the term "enhanced recovery after surgery" was introduced to replace "fast track recovery," emphasizing the concept of improving postoperative outcomes rather than just accelerating the perioperative time.

ERAS Concept

Henrik Kehlet, a Danish surgeon, was the first to introduce the concept of ERAS. He attributed lengthy recovery to the surgical stress response, metabolic, and endocrinal changes which adversely affect organ function after surgery [8]. Dr. Kehlet advocated that no single perioperative intervention can modify these physiological disturbances. Acknowledging the impact of many processes on patient recovery, Kehlet and Mogensen published a study to report the feasibility and efficacy of a multimodal rehabilitation regimen in promoting the postoperative recovery of patients undergoing open sigmoidectomy [10]. They used a combination of regional analgesia, and early postoperative oral intake and ambulation and demonstrated ability to reduce length of stay from 10 to 2 days [10]. These striking results attracted the attention of a group of European surgeons, and encouraged them to create a specific research group interested in ERAS.

ERAS Research Group

The first official ERAS study group was set up in 2001 by five different European medical centers from Denmark, Norway, Netherlands, Sweden, and the UK. The group established a single common ERAS protocol to be implemented by the

members in the group. However, adherence of each center to the protocol was not the same, resulting in different outcomes [2]. Discrepancy in the outcomes encouraged the group to create a shared database and record their practices. This database facilitated transparency and evaluation of the current practices among the incorporated centers, and correction of any deviation from the established common protocol.

ERAS Society

As the group expanded with clinician researchers joining from different countries, it was decided to establish an international ERAS organization to facilitate standardization and regular evaluation of the perioperative practices among the participating centers. In 2010, the ERAS Society was set up as a non-profit international organization in Stockholm, Sweden and included members of different roles involved in perioperative care [2]. Two years later, the ERAS Society started their annual International Congress to discuss, evaluate, and widely spread the current state of ERAS recommendations and to guide research future directions [6]. Recently in 2016, the American Society for Enhanced Recovery was created as an extension to the original ERAS Society, and the first United States of America ERAS Annual Congress was held in Dallas, Texas in November 2017.

Future Trends

Future of ERAS Practices

Despite the wide-spread discussion of ERAS concepts in the literature, and the evidence of its positive results in clinical trials, there is limited implementation of ERAS elements in real practice [24]. When ERAS was first described, it was formed of a few key elements (regional analgesia, early feeding, and ambulation) intended to facilitate consistent compliance [25, 26]. That is why incorporation of less significant components may make ERAS practices more complex, and adversely affect the healthcare team compliance and clinical progress [27, 28]. For example, carbohydrate-loading drinks have been introduced to provide preoperative nutritional optimization, less thirst, hunger, and anxiety with more patient comfort [29, 30]. However, no differences in postoperative outcomes have been shown when carbohydrates loading group compared with clear water or placebo groups [31]. Similarly, goal-directed fluid therapy (GDFT) has been preferred in high-risk patients undergoing major surgery with major fluid shift [32]. However, GDFT effects have been offset when compared with more wise fluid therapy in the setting of ERAS [33, 34]. Additionally, a univariate analysis of ERAS elements reported by Maessen et al. proposed that more compliance to postoperative rather than preoperative and perioperative elements has a higher impact on reducing the length of stay [35]. Hence, directing future research and practices toward procedure-specific ERAS elements may afford better compliance and implementation of ERAS [24]. Furthermore, ERAS is a multidisciplinary perioperative approach, and protocol implementation necessitates collaborative work between healthcare team members. Hence, focusing of multidisciplinary team-building should be prioritized to ensure higher compliance and consistent results [24].

ERAS and Technologies

Development of new technologies has shown positive impact on ERAS practices [12]. The use of esophageal Doppler, pneumatic leg compressors, and forced air-warming units are examples of the technologies that have helped clinical progress and better implementation of ERAS elements [36–38]. Recently, the advancement of wearable physical activity devices has enabled preoperative and postoperative monitoring and recording of patient activities [39, 40]. Involvement of such devices in ERAS practices will ensure continuous monitoring and encourage better adherence of the patient to physical activity which in turn will allow early mobilization and subsequent enhanced recovery [12]. Moreover, using smartphone new apps as a part of the perioperative care is emerging in the literature [41, 42]. These interactive apps have been designed and developed to improve communication between patients and their healthcare provider by creating conversations and a timely feedback. It is also meant to encourage patient adherence to ERAS protocol by providing a checklist and reminders throughout the whole perioperative journey. Published data has revealed that using these apps is feasible and acceptable [42]. However, further large sample studies are recommended to validate the current results, and to investigate and overcome barriers to using this new feature [41].

Future Research Directions

Future research should focus on studying and evaluating the sequences of perioperative complications and whether surgical complications lead to medical ones or vice versa while implementing ERAS [43]. Assessment of these complications will help in directing the appropriate management toward the initial complication and prevent its further progress [44]. Currently, most of the ERAS studies focus on the assessment of immediate postoperative outcomes, with limited data on post-discharge consequences. These consequences should be considered in the future studies to give a bigger and honest picture of ERAS impact on patients' recovery [24]. Due to the mutlimodal nature of ERAS protocol, there is limited data on determining the impact of each individual component on postoperative outcomes [45]. Thus, investigating the impact of

ERAS elements separately should be considered in the future research to help refining the current practices.

Educational Future

At the Educational level, expanding the concept of ERAS to the future generations of healthcare providers is a helpful way of facilitating its future implementation [46, 47]. Educating physicians and nurses in-training about ERAS will build a generation of believers in ERAS with a better background in its practices [46, 48, 49]. Having an early foundation will facilitate future replacement of the current traditional practices with ERAS [48, 50]. In addition, every hospital should establish a perioperative medicine program with regular learning rounds and sessions whenever possible, to boost the educational process and ensure a higher compliance to ERAS practices [49, 51].

ERAS Society Future

Regarding the future of the ERAS Society, it should work more on expanding collaborations with other societies [52]. These collaborations will allow greater spread and acceptance of its objectives. Furthermore, holding international congresses, and national and local symposia will provide good communication and collaboration between different researchers with better dialog from different insights [52].

Summary

Enhanced recovery pathways reduce overall costs including facilitating earlier discharge from hospitals after surgery. Overall, this chapter described ways to enhance surgical recovery pathways to continue to grow presence in healthcare practice. And although many clinical teams have yet to incorporate enhanced recovery pathway principles to their practices, increasing outreach and formalized guidelines in the future should help to ameliorate this lack of participation. The more available these guidelines are the more cooperation healthcare as a whole will have with compliance toward ERAS and surgical recovery.

Compliance with Ethical Standards

Conflict of Interest Amir Elhassan, Ahmed Ahmed, Hamdy Awad, Michelle Humeidan, Viet Nguyen, Elyse M. Cornett, Richard D. Urman, and Alan David Kaye declare no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:
- • Of importance
- •• Of major Importance

1. Porter ME. What is value in health care? N Engl J Med [Internet]. 2010 [cited 2018 Feb 16];363:2477–81. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21142528.
2. •• Ljungqvist O, Young-Fadok T, Demartines N. The history of enhanced recovery after surgery and the eras society. J Laparoendosc Adv Surg Tech [Internet]. 2017 [cited 2017 Nov 15];27:860–2. Available from: http://www.ncbi.nlm.nih.gov/pubmed/28795858 **Excellent review of the history of ERAS.**
3. Ljungqvist O, Young-Fadok T, Demartines N. The history of enhanced recovery after surgery and the ERAS Society. J Laparoendosc Adv Surg Tech [Internet]. 2017 [cited 2018 Feb 16];27:860–2. Available from: http://www.ncbi.nlm.nih.gov/pubmed/28795858
4. Li L, Jin J, Min S, Liu D, Liu L. Compliance with the enhanced recovery after surgery protocol and prognosis after colorectal cancer surgery: a prospective cohort study. Oncotarget [Internet]. Impact Journals, LLC; 2017 [cited 2018 Feb 16];8:53531–41. Available from: http://www.ncbi.nlm.nih.gov/pubmed/28881829
5. •• Gotlib Conn L, McKenzie M, Pearsall EA, McLeod RS. Successful implementation of an enhanced recovery after surgery programme for elective colorectal surgery: a process evaluation of champions' experiences. Implement Sci [Internet]. BioMed Central; 2015 [cited 2018 Feb 16];10:99. Available from: http://www.ncbi.nlm.nih.gov/pubmed/26183086 **Excellent manuscript on ERAS for elective colorectal surgery.**
6. Ljungqvist O, Scott M, Fearon KC. Enhanced recovery after surgery. JAMA Surg [Internet]. American Medical Association; 2017 [cited 2017 15];152:292. Available from: doi: https://doi.org/10.1001/jamasurg.2016.4952
7. Husted H, Lunn TH, Troelsen A, Gaarn-Larsen L, Kristensen BB, Kehlet H. Why still in hospital after fast-track hip and knee arthroplasty? Acta Orthop [Internet]. 2011 [cited 2018 Feb 16];82:679–84. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22066560
8. Kehlet H. Multimodal approach to control postoperative pathophysiology and rehabilitation. Br J Anaesth. 1997;78:606–17.
9. Fearon KCH, Ljungqvist O, Von Meyenfeldt M, Revhaug A, Dejong CHC, Lassen K, et al. Enhanced recovery after surgery: a consensus review of clinical care for patients undergoing colonic resection. Clin Nutr [Internet]. 2005 [cited 2018 Feb 14];24:466–77. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15896435
10. Kehlet H, Mogensen T. Hospital stay of 2 days after open sigmoidectomy with a multimodal rehabilitation programme. Br J Surg [Internet]. 1999 [cited 2017 Nov 15];86:227–30. Available from: http://www.ncbi.nlm.nih.gov/pubmed/10100792
11. Zhuang C-L, Huang D-D, Chen F-F, Zhou C-J, Zheng B-S, Chen B-C, et al. Laparoscopic versus open colorectal surgery within enhanced recovery after surgery programs: a systematic review and meta-analysis of randomized controlled trials. Surg Endosc [Internet]. 2015 [cited 2018 Feb 16];29:2091–100. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25414064
12. Abeles A, Kwasnicki RM, Darzi A. Enhanced recovery after surgery: current research insights and future direction. World J Gastrointest Surg [Internet]. 2017 [cited 2018 Feb 16];9:37. Available from: http://www.ncbi.nlm.nih.gov/pubmed/28289508

13.•• Carmichael JC, Keller DS, Baldini G, Bordeianou L, Weiss E, Lee L, et al. Clinical practice guidelines for enhanced recovery after colon and rectal surgery from the American Society of Colon and Rectal Surgeons and Society of American Gastrointestinal and Endoscopic Surgeons. Dis *Colon rectum* [Internet]. 2017 [cited 2018 Feb 14];60:761–84. Available from: http://www.ncbi.nlm.nih.gov/pubmed/28682962 **Excellent guidelines for ERAS from the American Society of Colon and Rectal Surgeons and Society of American Gastrointestinal and Endoscopic Surgeons.**

14. Temple-Oberle C, Shea-Budgell MA, Tan M, Semple JL, Schrag C, Barreto M, et al. Consensus review of optimal perioperative care in breast reconstruction. Plast Reconstr Surg [Internet]. 2017 [cited 2018 Jan 30];139:1056e–1071e. Available from: http://www.ncbi.nlm.nih.gov/pubmed/28445352

15. Dort JC, Farwell DG, Findlay M, Huber GF, Kerr P, Shea-Budgell MA, et al. Optimal perioperative care in major head and neck cancer surgery with free flap reconstruction. JAMA Otolaryngol Neck Surg [Internet]. 2017 [cited 2018 Feb 16];143:292. Available from: http://www.ncbi.nlm.nih.gov/pubmed/27737447.

16. Thorell A, MacCormick AD, Awad S, Reynolds N, Roulin D, Demartines N, et al. Guidelines for perioperative care in bariatric surgery: Enhanced Recovery After Surgery (ERAS) Society Recommendations. World J Surg [Internet]. 2016 [cited 2018 Feb 15];40:2065–83. Available from: http://www.ncbi.nlm.nih.gov/pubmed/26943657

17. Nelson G, Altman AD, Nick A, Meyer LA, Ramirez PT, Achtari C, et al. Guidelines for postoperative care in gynecologic/oncology surgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations — Part II. Gynecol Oncol [Internet]. 2016 [cited 2017 Nov 15];140:323–32. Available from: http://www.ncbi.nlm.nih.gov/pubmed/26757238

18. Zhu S, Qian W, Jiang C, Ye C, Chen X. Enhanced recovery after surgery for hip and knee arthroplasty: a systematic review and meta-analysis. Postgrad Med J [Internet]. The Fellowship of Postgraduate Medicine; 2017 [cited 2017 Nov 10];postgradmedj-2017-134991. Available from: http://www.ncbi.nlm.nih.gov/pubmed/28751437

19. Collins JW, Patel H, Adding C, Annerstedt M, Dasgupta P, Khan SM, et al. Enhanced recovery after robot-assisted radical cystectomy: EAU Robotic Urology Section Scientific Working Group Consensus View. Eur Urol [Internet]. 2016 [cited 2018 Feb 16];70:649–60. Available from: http://www.ncbi.nlm.nih.gov/pubmed/27234997

20. Nelson G, Altman AD, Nick A, Meyer LA, Ramirez PT, Achtari C, et al. Guidelines for pre- and intra-operative care in gynecologic/oncology surgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations — Part I. Gynecol Oncol [Internet]. 2016 [cited 2018 Feb 16];140:313–22. Available from: http://www.ncbi.nlm.nih.gov/pubmed/26603969.

21. Lassen K, Coolsen MME, Slim K, Carli F, De Aguilar-Nascimento JE, Schäfer M, et al. Guidelines for perioperative care for pancreaticoduodenectomy: Enhanced Recovery After Surgery (ERAS®) society recommendations. World J Surg Elsevier Ltd. 2013;37:240–58.

22. Engelman RM, Rousou JA, Flack JE, Deaton DW, Humphrey CB, Ellison LH, et al. Fast-track recovery of the coronary bypass patient. Ann Thorac Surg [Internet]. 1994 [cited 2018 Feb 16];58:1742–6. Available from: http://www.ncbi.nlm.nih.gov/pubmed/7979747

23. Krohn BG, Kay JH, Mendez MA, Zubiate P, Kay GL. Rapid sustained recovery after cardiac operations. J Thorac Cardiovasc Surg [Internet]. 1990 [cited 2018 Feb 16];100:194–7. Available from: http://www.ncbi.nlm.nih.gov/pubmed/2385117

24. Kehlet H. Enhanced Recovery After Surgery (ERAS): good for now, but what about the future? Can J Anesth Can d'anesthésie [Internet]. 2015 [cited 2018 Feb 16];62:99–104. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25391731

25. Kehlet H, Wilmore DW. Evidence-based surgical care and the evolution of fast-track surgery. Ann Surg [Internet]. 2008 [cited 2018 Feb 14];248:189–98. Available from: http://www.ncbi.nlm.nih.gov/pubmed/18650627

26. Kehlet H. Fast-track colorectal surgery. Lancet [Internet]. 2008 [cited 2018 Feb 16];371:791–3. Available from: http://www.ncbi.nlm.nih.gov/pubmed/18328911

27. Slim K, Kehlet H. Commentary: Fast track surgery: the need for improved study design. Color Dis [Internet]. 2012 [cited 2018 Feb 16];14:1013–4. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22834803

28. Vlug MS, Bartels SAL, Wind J, Ubbink DT, Hollmann MW, Bemelman WA, et al. Which fast track elements predict early recovery after colon cancer surgery? Color Dis [Internet]. 2012 [cited 2018 Feb 16];14:1001–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21985079

29. Brady MC, Kinn S, Stuart P, Ness V. Preoperative fasting for adults to prevent perioperative complications. Cochrane Database Syst Rev [Internet]. 2003 [cited 2018 Jan 30];CD004423. Available from: http://www.ncbi.nlm.nih.gov/pubmed/14584013.

30. Hausel J, Nygren J, Lagerkranser M, Hellström PM, Hammarqvist F, Almström C, et al. A carbohydrate-rich drink reduces preoperative discomfort in elective surgery patients. Anesth Analg [Internet]. 2001 [cited 2018 Feb 16];93:1344–50. Available from: http://www.ncbi.nlm.nih.gov/pubmed/11682427.

31. Amer MA, Smith MD, Herbison GP, Plank LD, McCall JL. Network meta-analysis of the effect of preoperative carbohydrate loading on recovery after elective surgery. Br J Surg [Internet]. 2017 [cited 2018 Feb 16];104:187–97. Available from: http://www.ncbi.nlm.nih.gov/pubmed/28000931

32. Benes J, Giglio M, Brienza N, Michard F. The effects of goal-directed fluid therapy based on dynamic parameters on post-surgical outcome: a meta-analysis of randomized controlled trials. Crit Care [Internet]. 2014 [cited 2018 Feb 16];18:584. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25348900.

33. Gómez-Izquierdo JC, Trainito A, Mirzakandov D, Stein BL, Liberman S, Charlebois P, et al. Goal-directed fluid therapy does not reduce primary postoperative ileus after elective laparoscopic colorectal surgery. Anesthesiology [Internet]. 2017 [cited 2018 Feb 16];127:36–49. Available from: http://www.ncbi.nlm.nih.gov/pubmed/28459732.

34. Srinivasa S, Taylor MHG, Singh PP, Lemanu DP, MacCormick AD, Hill AG. Goal-directed fluid therapy in major elective rectal surgery. Int J Surg [Internet]. Elsevier; 2014 [cited 2018 Feb 16];12:1467–72. Available from: https://www.sciencedirect.com/science/article/pii/S1743919114009704

35. Maessen J, Dejong CHC, Hausel J, Nygren J, Lassen K, Andersen J, et al. A protocol is not enough to implement an enhanced recovery programme for colorectal resection. Br J Surg [Internet]. 2007 [cited 2018 Feb 16];94:224–31. Available from: http://www.ncbi.nlm.nih.gov/pubmed/17205493

36. Pavon JM, Adam SS, Razouki ZA, McDuffie JR, Lachiewicz PF, Kosinski AS, et al. Effectiveness of intermittent pneumatic compression devices for venous thromboembolism prophylaxis in high-risk surgical patients: a systematic review. J Arthroplasty [Internet]. 2016 [cited 2018 Feb 16];31:524–32. Available from: http://www.ncbi.nlm.nih.gov/pubmed/26525487.

37. John M, Crook D, Dasari K, Eljelani F, El-Haboby A, Harper CM. Comparison of resistive heating and forced-air warming to prevent inadvertent perioperative hypothermia. Br J Anaesth [Internet]. Oxford University Press; 2016 [cited 2018 16];116:249–54. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0007091217304841

38. Colquhoun DA, Roche AM. Oesophageal Doppler cardiac output monitoring: A longstanding tool with evolving indications and applications. Best Pract Res Clin Anaesthesiol [Internet]. 2014 [cited

2018 Feb 16];28:353–62. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25480766.

39. Aziz O, Atallah L, Lo B, Gray E, Athanasiou T, Darzi A, et al. Ear-worn body sensor network device: an objective tool for functional postoperative home recovery monitoring. J Am Med Inform Assoc [Internet]. American Medical Informatics Association; 2011 [cited 2018 Feb 16];18:156–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21252051
40. Brown CJ, Redden DT, Flood KL, Allman RM. The underrecognized epidemic of low mobility during hospitalization of older adults. J Am Geriatr Soc [Internet]. 2009 [cited 2018 Feb 16];57:1660–5. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19682121.
41. Scott AR, Alore EA, Naik AD, Berger DH, Suliburk JW. Mixed-methods analysis of factors impacting use of a postoperative mHealth App. JMIR mHealth uHealth [Internet]. JMIR mHealth and uHealth; 2017 [cited 2018 16];5:e11. Available from: http://mhealth.jmir.org/2017/2/e11/
42. Semple JL, Sharpe S, Murnaghan ML, Theodoropoulos J, Metcalfe KA. Using a mobile App for monitoring post-operative quality of recovery of patients at home: a feasibility study. JMIR mHealth uHealth [Internet]. 2015 [cited 2018 Feb 16];3:e18. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25679749
43. Kehlet H, Mythen M. Why is the surgical high-risk patient still at risk? Br J Anaesth [Internet]. Oxford University Press; 2011 [cited 2018 Feb 16];106:289–91. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0007091217329896
44. Kehlet H, Slim K. The future of fast-track surgery. Br J Surg [Internet]. 2012 [cited 2018 Feb 16];99:1025–6. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22696149.
45. Jurt J, Slieker J, Frauche P, Addor V, Solà J, Demartines N, et al. Enhanced recovery after surgery: can we rely on the key factors or do we need the Bel Ensemble? World J Surg [Internet]. 2017 [cited 2018 Feb 16];41:2464–70. Available from: http://www.ncbi.nlm.nih.gov/pubmed/28492998
46. Nadler A, Pearsall EA, Charles Victor J, Aarts M-A, Okrainec A, McLeod RS. Understanding surgical residents' postoperative practices and barriers and enablers to the implementation of an Enhanced Recovery After Surgery (ERAS) Guideline. J Surg Educ [Internet]. 2014 [cited 2018 Feb 16];71:632–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24810857
47. Herbert G, Sutton E, Burden S, Lewis S, Thomas S, Ness A, et al. Healthcare professionals' views of the enhanced recovery after surgery programme: a qualitative investigation. BMC Health Serv Res [Internet]. BioMed Central; 2017 [cited 2018 Feb 16];17:617. Available from: doi: https://doi.org/10.1186/s12913-017-2547-y
48. Montgomery R, McNamara SA. Multimodal pain management for enhanced recovery: reinforcing the shift from traditional pathways through nurse-led interventions. AORN J [Internet]. 2016 [cited 2018 Feb 16];104:S9–16. Available from: doi: https://doi.org/10.1016/j.aorn.2016.10.012
49. McLeod RS, Aarts M-A, Chung F, Eskicioglu C, Forbes SS, Conn LG, et al. Development of an enhanced recovery after surgery guideline and implementation strategy based on the knowledge-to-action cycle. Ann Surg. 2015;262:1016–25.
50. Pearsall EA, Meghji Z, Pitzul KB, Aarts M-A, McKenzie M, McLeod RS, et al. A qualitative study to understand the barriers and enablers in implementing an enhanced recovery after surgery program. ann surg [internet]. 2015 [cited 2018 Feb 16];261:92–6. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24646564
51. King AB, Alvis BD, McEvoy MD. Enhanced recovery after surgery, perioperative medicine, and the perioperative surgical home. Curr Opin Anaesthesiol [Internet]. 2016 [cited 2017 Nov 15];29:727–32. Available from: http://www.ncbi.nlm.nih.gov/pubmed/27652514
52. Ljungqvist O. ERAS—Enhanced Recovery After Surgery. J Parenter Enter Nutr [Internet]. 2014 [cited 2018 Feb 16];38:559–66. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24567343