Introduction of Oesophageal Doppler-Guided Fluid Management in a Laparoscopic Colorectal Surgery Enhanced Recovery Programme: An Audit of Effect on Patient Outcome

Abstract:

M McKenny, C O'Malley, B Mehigan, P McCormick, N Dowd
St Jamesâ s Hospital, Jamesâ s St, Dublin 8

Abstract

Morbidity after colorectal surgery can be reduced with intraoperative oesophageal Doppler monitor (ODM) guided fluid therapy. We audited the effect of introducing ODM-guided fluid therapy in enhanced recovery laparoscopic colorectal surgery. ODM group (n=40) outcomes (toleration of diet, Post Operative Morbidity Survery (POMS) score, complications) were compared to matched patients (n=40) who had the same surgery using a conventional approach to fluid management. Mean (SD) time to tolerate diet was shorter in the ODM group (2.3 (1.6) days vs 3.8 (2.4) days, p = 0.003). The ODM group had a lower mean (SD) POMS score on post-operative day 1 (2 (1.4) vs 4 (1.1), p = 0.001), fewer postoperative complications (14 patients vs 20, p=0.009) and a lower rate of unplanned critical care area admission (1 vs 6, p= 0.001). Introduction of intraoperative ODM-guided stroke volume optimization was associated with improved outcomes in patients undergoing enhanced recovery laparoscopic colorectal surgery.

Introduction

When conventional haemodynamic indices, including blood pressure and heart rate, are used to guide intravenous fluid administration intraoperatively they may not disclose occult hypovolaemia, a volume-depleted state that is associated with worse outcome[1,2]. The use of fixed-volume fluid protocols can lead to hypervolaemia and tissue oedema, which is also associated with increased morbidity[3,4]. Therefore, much interest has focused on methods of monitoring intravascular volume status to guide individualised fluid therapy during major surgery[5]. The oesophageal Doppler Monitor (ODM) is a minimally invasive cardiac output monitor, that, when used with a stroke volume (SV) optimisation algorithm, can guide fluid therapy during surgery to enhance global and regional tissue perfusion and has been shown to improve outcomes in a variety of surgical settings[2,6-11]. In patients undergoing colorectal surgery, ODM-guided fluid administration has been found to enhance recovery of gut function postoperatively, reduce complications and hospital length of stay[7-9]. The National Institute for Clinical Excellence and other organisations recommend that clinicians consider using the ODM in patients undergoing major or high-risk surgery[12,13].

A colorectal surgery enhanced recovery pathway, together with an ongoing audit of patient outcomes, is well established at our institution. This pathway lacked an intraoperative fluid management component, so based on the evidence of improved outcome in colorectal surgery with ODM-guided intraoperative fluid therapy, we introduced this monitoring modality. We report the clinical audit performed as an integral part of this quality improvement change in our enhanced recovery laparoscopic colorectal surgery patient population[14].

Methods

The audit design permitted postoperative outcomes of ASA 1-3 adult patients undergoing elective laparoscopic colorectal surgery with intraoperative ODM fluid management during 2011 (ODM group) to be compared to the outcomes of patients who had the same surgical procedures with conventional fluid management (conventional group). Both groups followed the same enhanced recovery pathway in all other respects. The ODM group had intraoperative ODM-guided fluid management using the Deltex CardioQ-ODM" (Deltex Medical, Chichester, West Sussex, UK). The conventional group comprised patients from the institutionâ s prospective colorectal surgery audit database who had undergone the same surgical procedure, but had intraoperative fluid therapy guided by conventional haemodynamic indices. Comparison of outcomes between the ODM and conventional groups was based on matching patients for age, procedure type, ASA grade, and Colorectal Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity (CR-POSSUM). Audit data was collected prospectively for both groups, and the groups ran consecutively. The audit proposal was submitted to the institutional Research Ethics Committee; the chairman reviewed the proposal on behalf of the committee and stated that ethical approval was not necessary.

Both groups received a similar anaesthetic; induction with fentanyl and propofol, tracheal intubation with rocuronium or atracurium, and maintenance with sevoflurane in oxygen and air and a remifentanil infusion. Standard monitoring included ECG, SpO2, capnography and invasive arterial pressure measurement. In the induction room ODM group patients had an ODM probe inserted into their oesophagus in accordance with the manufacturer's instructions. Multimodal post-operative analgesia comprised paracetamol, NSAIDs and morphine patient controlled analgesia. No regional anaesthesia techniques were used. The ODM group fluid management algorithm (Figure 1) was based on RCT algorithms that demonstrated improved outcome in colorectal surgery patients[7-10]. The fluid used in this algorithm was 6% Hydroxyethyl Starch (HES) (Voluven, Fresenius Kabi AG, Bad Homburg, Germany) Stroke volume optimization with the ODM was undertaken prior to initial pneumoperitoneum, and during the â openâ phase of the laparoscopic procedure, but not when pneumoperitoneum was present. The ODM probe was removed at the end of the procedure. Conventional group intraoperative fluid management was at the discretion of the attending anaesthetist using conventional hemodynamic indices.

Outcomes audited were time to tolerate oral diet post-operatively, Post Operative Morbidity Survey (POMS) score, overall organ-specific complication rate, unplanned critical care area (HDU/ICU) admission rate and length of postoperative hospital stay. POMS score is a validated tool that assigns a score for the presence or absence of predefined postoperative organ-specific complications[15,16]. A member of the surgical team who was not present in the operating room undertook postoperative patient data collection. The first post-operative day was assigned day 1 for the purpose of calculating length of hospital stay. Timing and volume of intraoperative crystalloid and colloid administration was recorded. Demographic and baseline characteristics were described using summary statistics for both groups. Our statistical analysis used Studentâ s t test for independent samples. McNemar's Chi Sq test was used for matched data. A p value <0.05 was considered statistically significant.

Results

The audit included 80 patients; 40 in the ODM group and 40 in the conventional group. Age, surgical procedure, ASA grade, physiological, operative and total CR-POSSUM score and duration of surgery were similar between the groups (Table 1). ODM group patients tolerated oral diet earlier than conventional group patients (2.3 (1.6) days vs 3.8 (2.4) days, p = 0.003) (Table 2). POMS score was lower on postoperative day 1 in the ODM group (2 (1.4) vs 4 (1.1), p = 0.001) (Table 2).

Fewer ODM group patients experienced 1 postoperative complication (14 vs 20, p=0.009) (Table 3). In the conventional group, gastrointestinal complications developed in 5 patients. These complications included one anastamotic haematoma, one small bowel obstruction requiring operative intervention and 2 high output stomas. The fifth patient had a prolonged ileus and required total parenteral nutrition (TPN). All of the gastrointestinal complications in the ODM group were ileus, 2 of which required TPN. Fewer patients in the ODM group required unplanned postoperative critical care admission (1 vs 6, p = 0.001) (Table 2). Reasons for critical care admission included lower respiratory tract infection, hypovolaemic shock, acute kidney injury and prolonged ileus. Length of critical care stay ranged from 1-2 days in the conventional group and was 7 days for the patient in the ODM group. There was no difference between groups in the mean (SD) length of postoperative hospital stay (days) (8.7 (4.3) in the ODM group and 9.6 (5.6) in the conventional group).

Total volume (mean (SD)) of fluid administered was not different between the groups; ODM group 2104 (904) ml vs. conventional group 2447 (958), p = 0.07). Patients in the ODM group received more colloid (964 (525) ml vs 371 (421) ml, p < 0.0001), and less crystalloid (1140 (614) ml vs. 2076 (807) ml, p < 0.0001). Patients in the ODM group received more colloid during the first hour of surgery (636 (355) ml vs 62 (156) ml, p < 0.0001). There were no differences in the volumes of colloid administered over subsequent hours of surgery between the 2 groups. In contrast, the ODM group patients received less crystalloid during every hour of surgery. There were no complications related to ODM probe insertion and no patients in the ODM group developed signs or symptoms of fluid overload or cardiac failure.

Discussion

This audit showed that intraoperative ODM-guided SV optimisation was associated with a reduction in postoperative morbidity in patients undergoing laparoscopic colorectal surgery. Time to tolerate diet was shorter, and complication rate, number of complications and unplanned critical care admission rate was significantly lower in the ODM group. Fewer patients in the ODM group experienced 1 postoperative complication (14 vs. 20, p = 0.009). Patients in the conventional group had more serious gastrointestinal morbidity. Splanchnic hypoperfusion may occur in up to 60% of patients undergoing major surgery, can affect gut mucosal functional integrity, and has been shown to be a strong predictor of postoperative GI morbidity[2,17-19]. Individualised timely optimization of stroke volume in the ODM group may have better maintained splanchnic perfusion and gut mucosal integrity and could explain the observed reduction in complication rate. The total volume of intravenous fluid administered to the 2 groups was not different. Therefore, the type and / or temporal pattern of intravenous fluid administration may explain the observed outcome differences. The ODM group received more colloid and less crystalloid than the conventional group. Colloids may have a benefit by maintaining splanchnic micro-circulation[20,21]. In the ODM group fluid administration was â front loadedâ ; they received a greater proportion of their total fluid in the first hour of surgery, prior to initiation of pneumoperitoneum and re-positioning of the patient from supine to Trendelenberg.

The sequence of operating room events in relation to the timing of fluid administration may be important in understanding the observed differences in outcome. Pneumoperitoneum during laparoscopic surgery is uniquely associated with acute cardiovascular changes, including reduced venous return, increased afterload and a reduction in SV and cardiac index[22]. Such haemodynamic responses to pneumoperitoneum may vary according to both the individual patient and the insufflation pressure[23]. These cardiovascular changes may be amplified by the steep Trendelenberg position necessitated by laparoscopic colorectal surgery and the variable degrees of dehydration that exist in this surgical population. It is plausible that this confluence of factors adversely affects tissue perfusion in patients undergoing laparoscopic surgery[23]. Early optimization of stroke volume prior to pneumoperitoneum with â front loadingâ of fluid may have a protective effect on the splanchnic circulation and gut mucosal integrity, and this may explain the lower rate of morbidity seen in the ODM compared to the conventional group who did not have this â front loadedâ pattern of fluid administration.

A potentially important effect may be observed from using the ODM to guide fluid administration only when pneumoperitoneum was absent. When pneumoperitoneum is introduced, reduced SV is detected by the ODM. If this reduced SV is inappropriately attributed to hypovolemia, rather than the physiological changes described above, and triggers further intravenous colloid administration, the risk of harmful iatrogenic fluid overload has been created. Thus, the observed improvement in outcome in the ODM group in this audit accords with the benefits that have been observed when an approach is taken to intraoperative fluid management that avoids salt and water excess[3,4]. This audit observed a reduction in postoperative complication rate, but no difference in length of postoperative hospital stay. The sample size may have been inadequate to detect any such difference, and length of stay may be influenced by non-medical factors. Time to fitness for medical discharge might be a more informative measure. Interestingly, the total number of bed days was 348 in the ODM group compared to 383 in the conventional group, which represents significant cost saving at our institution on this metric.

On the basis of evidence of improved outcome and the published recommendations we introduced intraoperative ODM-guided fluid management as a quality improvement measure to an existing enhanced recovery pathway in laparoscopic colorectal surgery. This clinical audit formed an important part of this process, and found that intraoperative ODM-guided stroke volume optimisation was associated with earlier toleration of diet, and a reduction in complication rate, total number of complications and unplanned critical care admission in patients undergoing laparoscopic colorectal surgery. This also illustrates the importance of audit when an evidence-based quality improvement change is implemented. Individualised fluid therapy has been adopted as one of the recommended elements for major elective surgical pathways by the Enhanced Recovery Partnership, and particularly in the area of laparoscopic surgery this has generated recent interest[13,24]. The predicted expansion of enhanced recovery pathways in the future is likely to make this an ongoing focus of interest.

Correspondence: M McKenny
Department of Anaesthesia and Pain Management, Toronto General Hospital, 200 Elizabeth St Toronto Ontario M5G 2C4
Email: Michael.Mckenny@uhn.ca

Acknowledgements

D Flannery, Colorectal Cancer Co-ordinator; R Greally, Specialist Registrar Anesthesia; R Jooste, Senior House Officer Anesthesia; J Larkin, Specialist Registrar Surgery; M Roberts, Administrative Officer, Dept. of Anesthesia; T Rooney, Surgical Intern, St Jamesâ s Hospital.

References

1. Hamilton-Davies C, Mythen MG, Salmon JB, Jacobson D, Shukla A: Comparison of commonly used clinical indicators of hypovolaemia with gastric tonometry. Intensive Care Med 1997; 23: 276-81.

2. Mythen MG, Webb AR: Intraoperative gut mucosal hypoperfusion is associated with increased post-operative complications and cost. Intensive Care Med 1994; 20: 99-104.

3. Holte K, Sharrock NE, Kehlet H. Pathophysiology and clinical implications of perioperative fluid excess. Brit J Anaesth 2002; 89: 622-32.

4. Nisanevich V, Felsenstein I, Almogy G, Weissman C, Einav S, Matot I. Effect of intraoperative fluid management on outcome after intraabdominal surgery. Anesthesiology 2005; 103: 25-32.

5. Bouwman R, Boer C. Minimal invasive cardiac output monitoring: get the dose of fluid right. Brit J Anaesth 2012; 109: 299-302.

6. Sinclair S, James S, Singer M. Intraoperative intravascular volume optimisation and length of hospital stay after repair of proximal femoral fracture: randomised controlled trial. Brit Med J 1997; 315: 909-12.

7. Noblett SE, Snowden CP, Shenton BK, Horgan AF. Randomized clinical trial assessing the effect of Doppler-optimized fluid management on outcome after elective colorectal resection. Brit J Surg 2006; 93: 1069-76.

8. Conway DH, Mayall R, Abdul-Latif MS. Randomised controlled trial investigating the influence of intravenous fluid titration using oesophageal Doppler monitoring during bowel surgery. Anaesthesia 2002; 57: 845-9.

9. Wakeling HG, McFall MR, Jenkins CS, Woods W, Miles W, Barclay G, Fleming S. Intraoperative oesophageal Doppler guided fluid management shortens postoperative hospital stay after major bowel surgery. Brit J Anaesth 2005; 95: 634-42.

10. Gan TJ, Soppitt A, Maroof M, El-Moalem H, Robertson K, Moretti E, Dwane P, Glass P. Goal-directed intraoperative fluid administration reduces length of hospital stay after major surgery. Anesthesiology 2002; 97: 820-6.

11. Giglio MT, Marucci M, Testini M, Brienza N. Goal-directed haemodynamic therapy and gastro-intestinal complications in major surgery: a meta-analysis of randomized controlled trials. Brit J Anaesth 2009; 103: 637-46.

12. NICE: National Institute for Health and Clinical Excellence. CardioQ-ODM oesophageal doppler monitor: Medical Technology guidance 3, March 2011. http://www.nice.org.uk/nicemedia/live/13312/52624/52624.pdf (accessed 01.06.2011)

13. Mythen M, Swart M, Acheson N, Crawford R, Jones K, Kuper M, McGrath J, Horgan A. Perioperative fluid management: Consensus statement from the enhanced recovery partnership. Perioperative Medicine 2012; 1: 2-5.

14. Healthcare audit criteria and guidance. Clinical Audit Criteria and Guidance Working Group. Health Services Executive: Dublin; 2008.

15. Bennett-Guerreo E, Welsby I, Dunn TJ, Young L, Wahl T, Diers T, Phillips-Bute B, Newman M, Mythen M. The use of a postoperative morbidity survey to evaluate patients with prolonged hospitalization after routine, moderate-risk, elective surgery. Anesth Analg 1999; 89: 514-9.

16. Grocott MPW, Browne JP, Van der Meulen J, Matejowsky C, Mutch M, Hamilton M, Levett D, Emberton M, Haddad F, Mythen M. The postoperative morbidity survey was validated and used to describe morbidity after major surgery. J Clin Epidemiol 2007; 60: 919-28.

17. Ceppa EP, Fuh KC, Bulkey GB. Mesenteric haemodynamic responses to circulatory shock. Current Opinion in Critical Care 2003; 9: 127-32.

18. Jakob SM, Takala J. Splanchnic haemodynamics in critical illness. Curr Opin Crit Care 2000; 6: 123-9.

19. Milan M, Garcia-Granero E, Flor B, Garcia-Botello S, Lledo S. Early prediction of anastamotic leak in colorectal cancer surgery by intramucosal pH. Dis Colon Rectum 2006; 49: 595-601.

20. Marjanovic G, Villain C, Timme S, zur Hausen A, Hoepnerr J, Makowiec F, Holzner P, Hopt UT, Obermaier R. Colloid vs. crystalloid infusions in gastrointestinal surgery and their different impact on the healing of intestinal anastamoses. Int J Colorectal Dis 2010; 25: 491-8.

21. Kimberger O, Arnberger M, Brandt S, Plock J, Sigurdsson G, Kurz A, Hiltebrand L. Goal-directed colloid administration improves the microcirculation of healthy and perianastamotic colon. Anesthesiology 2009; 110: 496-504.

22. Odeberg S, Ljungqvist O, Svenberg T, Gannedahl P, Backdahl M, von Rosen A, Sollevi A. Haemodynamic effects of pneumoperitoneum and the influence of posture during anaesthesia for laparoscopic surgery. Acta Anesthesiol Scand 1994; 38: 276-83.

23. Alishahi S, Francis N, Croft S, Duncan L, Bickel A, Cushieri A. Central and peripheral adverse haemodynamic changes during laparoscopic surgery and their reversal with a novel intermittent sequential pneumatic compression device. Ann Surg 2001; 233: 176-82.

24. Brandstrup B, Svensen P, Rasmussen M, Belhage B, Rodt S, Hansen B, Moller D, Lundbech L, Andersen N, Berg V, Thomassen N, Andersen S, Simonsen L. Which goal for fluid therapy during colorectal surgery is followed by the best outcome: near-maximal stroke volume or zero fluid balance? British J Anaesth 2012; 109: 191-9.