



Nationwide variations in the execution of minimally invasive right hemicolectomy and short-term outcomes: first phase of the RIGHT study

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Although minimally invasive right hemicolectomy (MIRH) has become the standard of care to treat patients with right-sided colon cancer, substantial variation in the execution and implementation of proven beneficial elements that impact clinical outcomes exists. Within the Dutch national RIGHT project, a Delphi consensus was conducted that established an evidence-based, standardized technique for MIRH, including: low intra-abdominal pressure (IAP), complete mesocolic excision (CME) with central dissection along the superior mesenteric vein (SMV) and central vascular ligation (CVL) of segmental vessels, an intracorporeal anastomosis, and specimen extraction through a Pfannenstiel incision (see [File S1](#) and [File S2](#))^{1,2}. The aim of the RIGHT project is to implement this standardized technique for MIRH nationwide in order to improve clinical outcomes. Within the first phase of the RIGHT study, the aim was to evaluate the nationwide variation of the elements of MIRH for right-sided colon cancer.

The RIGHT study is a multicentre national prospective cohort study, that started in October 2021 in the Netherlands, with 43 participating hospitals (43 of 71 = 60.6% of Dutch hospitals). Patients undergoing planned MIRH (both conventional laparoscopic and robot-assisted) for right-sided non-locally advanced stage 1–3 colon cancer were included. During the first phase (October 2021–August 2022), participating surgeons were instructed to perform the MIRH according to their routine practice. An essential aspect of this study is that surgeons were required to make a video recording of the entire procedure and to take a picture of both the front and back of the specimen. The quality of mesocolic excision was scored according to Benz, ranging from 0 to 3, where a lower score indicates a more extensive mesocolic excision, with Benz 0 corresponding to CME³.

A total of 414 patients were included in phase 1. See [Fig. S1](#) for the inclusion flowchart and [Table S1](#) for the baseline patient characteristics. [Table 1](#) provides an overview of all procedural

variations within MIRH among the participating Dutch surgeons. The median IAP applied during surgery was 12 mmHg, ranging from 7 to 15 mmHg. Anastomoses were most often performed intracorporeally (80.9%), mostly in an isoperistaltic configuration (80.7%), and almost exclusively constructed using a stapler (96.3%). In 77.3% of cases, the specimen was extracted through a Pfannenstiel incision. The distribution of the Benz classification was as follows: 23% of cases were Benz 0, 30% of cases were Benz 1, 37% of cases were Benz 2, and 10% of cases were Benz 3. [Fig. S2](#) provides some examples of the different Benz categories. [Table S2](#) summarizes 90-day postoperative complications, which occurred in 25.9% of cases. Anastomotic leakage was noted in 2.7% of cases and the 90-day mortality rate was 0.7%. The median duration of hospital stay was 3 days and the readmission rate was 10.5%.

This first phase of the RIGHT study shows that, in the participating hospitals, a high percentage of MIRH operations are performed with the established evidence-based ‘new’ techniques (such as intracorporeal anastomosis and Pfannenstiel extraction) and with acceptable short-term morbidity. However, specimen evaluation demonstrated that a minority of the patients underwent a CME with central SMV dissection and CVL of segmental vessels, implying that this recent development and guideline recommendation is not yet broadly implemented in the Netherlands.

An intact mesocolon with central ligation of the vessels (optimal D2 dissection, thus CME) is believed to reduce the risk of recurrence and improve long-term survival^{4,5}. Controversy exists in the literature regarding the definition of CME and whether a D3 dissection is an integral part of CME⁶. However, SMV dissection with CVL alone should result in a good-quality D2 dissection, resulting in a specimen that contains a surgical trunk medial to the supraduodenal window that connects the ileocolic and right colic pedicles. The recent RELARC trial did not

Table 1 Overview of variations within minimally invasive right hemicolectomy

Variation	Value
Preoperative oral antibiotics, n of n (%)	64 of 414 (15.5)
Bowel preparation	
None	370 (90.0)
Mechanical bowel preparation	36 (8.8)
Enema	4 (1.0)
Mechanical bowel preparation + enema	1 (0.2)
Patient position	
Supine	307 (75.6)
French	85 (20.9)
Lithotomy using stirrups	14 (3.4)
Minimally invasive approach	
Laparoscopic	382 (92.7)
Robot-assisted	30 (7.3)
Number of trocars	
3	20 (4.9)
4	334 (81.7)
5	50 (12.2)
>5	5 (1.2)
Intra-abdominal pressure (mmHg), median (interquartile range; range)	12 (12–12; 7–15)
Approach for retroperitoneal dissection	
Medial to lateral (through the ileal mesentery)	370 (90.5)
Lateral to medial	15 (3.7)
Caudal to cranial (subileal)	23 (5.6)
Cranial to caudal	1 (0.2)
Indocyanine Green applied, n of n (%)	68 of 410 (16.6)
Anastomosis	
Intracorporeal	331 (80.9)
Extracorporeal	78 (19.1)
Isoperistaltic	330 (80.7)
Antiperistaltic	79 (19.3)
Handsewn	15 (3.7)
Stapled	394 (96.3)
Extraction site	
Left lower quadrant	2 (0.5)
Transverse	16 (3.9)
Pfannenstiel	316 (77.3)
Right lower quadrant	7 (1.7)
Umbilical (midline)	49 (12.0)
Other	19 (4.6)
Specimen according to Benz classification*	
Benz 0	60 (23.0)
Benz 1	78 (30.0)
Benz 2	96 (36.9)
Benz 3	26 (10.0)

Values are n (%) unless otherwise indicated. *Benz classification: Benz 0 (true complete mesocolic excision specimen), the stalks of the ileocolic vessels and middle colic vessels are connected by tissue of the surgical trunk (lymphatic tissue package covering the superior mesenteric vein) and the mesocolic window has a complete medial frame of mesocolic tissue; Benz 1, the stalks of the ileocolic and middle colic vessels are present, but are not connected by tissue, and the frame of the mesocolic window is not complete with regard to its medial aspect; Benz 2, the stalks of the ileocolic vessels are present, with more than 50% of the anticipated length according to the geometric configuration of the specimen, but the middle colic vessels are not detectable, and the frame of the window has medial and cranial defects; and Benz 3, the ileocolic vessels have an amputated appearance (less than 50% of the anticipated length according to the geometric configuration of the specimen) and the window is not detectable.

show superiority regarding 3-year disease-free survival of extended D3 dissection *versus* D2 dissection⁷. However, both study groups underwent CVL with the aim of an intact mesocolic specimen. The fact that an optimal D2 dissection was achieved in only a minority of the patients in the present study highlights the importance of implementation programmes to help the surgical community to adapt to the recommendations of up-to-date guidelines.

An intracorporeal anastomosis was performed in a remarkably high proportion of patients. Several systematic reviews have highlighted the benefits of intracorporeal anastomosis *versus*

extracorporeal anastomosis in MIRH, showing reduced short-term morbidity, decreased duration of hospital stay, and quicker recovery of bowel function⁸. Similarly, the use of a Pfannenstiel incision for specimen extraction in the present study is higher than generally reported. The previous literature consistently reports that Pfannenstiel extraction is advantageous for patients, with a lower incisional hernia rate compared with midline and other incisions⁹. The median IAP applied in this study was 12 mmHg. A recent RCT has demonstrated that maintaining a lower IAP at 8 mmHg, in comparison with 12 mmHg, resulted in decreased acute pain scores, a reduction in 30-day infectious complications, diminished surgical-site hypoxia and inflammatory markers, reduced postoperative cytokine production, and a higher-quality recovery¹⁰.

In the next phases of the RIGHT study, all key elements of the consensus-based standardized technique for MIRH will be included in training and proctoring, with continuous monitoring, including video recording, specimen pictures, CT imaging and clinical outcomes. This means that CME with SMV dissection and CVL will be performed using an 8 mmHg pneumoperitoneum, when possible, followed by an intracorporeal anastomosis with Pfannenstiel extraction.

In conclusion, during phase 1 of the RIGHT study, participating surgeons have already incorporated parts of the optimal technique for MIRH, such as intracorporeal anastomosis and Pfannenstiel extraction. However, there was still significant variability in certain steps, such as the extent of mesocolic excision and IAP. An optimal D2 dissection, and thus a CME, was achieved in only a minority of patients. This underscores the importance of the RIGHT project as a crucial initiative for the nationwide implementation of an optimized technique for MIRH, with the aim of improving both short- and long-term outcomes for patients with right-sided colon cancer.

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Disclosure

The authors declare that they have no conflicts of interest.

Supplementary material

Supplementary material is available at *BJS* online.

Data availability

The study data are not openly available. The authors are willing to share the data, upon reasonable request.

References

1. Grüter AAJ, Toorenvliet BR, Belgers EHJ, Belt EJT, van Duijvendijk P, Hoff C *et al.*; Right collaborators group. Nationwide standardization of minimally invasive right hemicolectomy for colon cancer and development and validation of a video-based competency assessment tool (the Right study). *Br J Surg* 2024;**111**:znad404
2. Grüter AAJ, Coblijn UK, Toorenvliet BR, Tanis PJ, Tuynman JB; Right Collaborators Group. National implementation of an optimal standardised technique for right-sided colon cancer: protocol of an interventional sequential cohort study (Right study). *Tech Coloproctol* 2023;**27**:1083–1090
3. Benz S, Tannapfel A, Tam Y, Grünenwald A, Vollmer S, Stricker I. Proposal of a new classification system for complete mesocolic excision in right-sided colon cancer. *Tech Coloproctol* 2019;**23**: 251–257
4. Bertelsen CA, Neuenschwander AU, Jansen JE, Tenma JR, Wilhelmsen M, Kirkegaard-Klitbo A *et al.* 5-year outcome after complete mesocolic excision for right-sided colon cancer: a population-based cohort study. *Lancet Oncol* 2019; **20**:1556–1565
5. West NP, Hohenberger W, Weber K, Perrakis A, Finan PJ, Quirke P. Complete mesocolic excision with central vascular ligation produces an oncologically superior specimen compared with standard surgery for carcinoma of the colon. *J Clin Oncol* 2010; **28**:272–278
6. Sica GS, Vinci D, Siragusa L, Sensi B, Guida AM, Bellato V *et al.* Definition and reporting of lymphadenectomy and complete mesocolic excision for radical right colectomy: a systematic review. *Surg Endosc* 2022;**37**:846–861
7. Lu J, Xing J, Zang L, Zhang C, Xu L, Zhang G *et al.* Extent of lymphadenectomy for surgical management of right-sided colon cancer: the randomized phase III RELARC trial. *J Clin Oncol* 2024; DOI: 10.1200/JCO.24.00393 [Epub ahead of print]
8. van Oostendorp S, Elfrink A, Borstlap W, Schoonmade L, Sietses C, Meijerink J *et al.* Intracorporeal versus extracorporeal anastomosis in right hemicolectomy: a systematic review and meta-analysis. *Surg Endosc* 2017;**31**:64–77
9. den Hartog FPJ, van Egmond S, Poelman MM, Menon AG, Kleinrensink GJ, Lange JF *et al.* The incidence of extraction site incisional hernia after minimally invasive colorectal surgery: a systematic review and meta-analysis. *Colorectal Dis* 2022;**25**: 586–599
10. Albers KI, Polat F, Helder L, Panhuizen IF, Snoeck MMJ, Polle SBW *et al.* Quality of recovery and innate immune homeostasis in patients undergoing low-pressure versus standard-pressure pneumoperitoneum during laparoscopic colorectal surgery (RECOVER): a randomized controlled trial. *Ann Surg* 2022;**276**:e664–e673