



EUROPEAN COLORECTAL CONGRESS

Spotlight on the colon

1 – 5 December 2019, St.Gallen, Switzerland

Sunday, 1 Dec. 2019

MASTERCLASS

09.00
When the appendix plays nasty: intraoperative surprises, immediate solutions, and long-term treatment options
Justin Davies, Cambridge, UK

09.40
All the secrets of the pelvic floor - common disorders and proven solutions
Julie Cornish, Cardiff, UK

10.20
taTME in 2020 – when the dust settles: current and innovative indications, implementation, and practical advices
Roel Hompes, Amsterdam, NL

11.30
Complete mesocolic excision: indications, surgical approaches, and pitfalls
Paris Tekkis, London, UK

12.10
The views of an Editor and the wisdom of an Expert: contemporary publications with the potential to change and improve practice
Neil Mortensen, Oxford, UK

14.00
To ostomize or not and when? The value and downside of a diverting stoma versus virtual ileostomy versus no stoma
Gabriela Möslein, Wuppertal, DE

14.40
Extended lymph node dissection: indications, surgical anatomy, and technical approaches
Peter Sagar, Leeds, UK

15.20
Is the longer the new better - how to safely extend the interval after neoadjuvant chemoradiotherapy prior to surgery for rectal cancer
Ronan O'Connell, Dublin, IE

16.30
The colorectal anastomosis: time-proven wisdom, innovative configurations, and salvage techniques
André d'Hoore, Leuven BE

17.10
All you need to know about stomas but never dared to ask
Willem Bemelman, Amsterdam, NL

17.50
The EBSQ Coloproctology Examination
Michel Adamina, Winterthur, CH

18.00
Wrap-up
Michel Adamina, Winterthur, CH

Monday, 2 Dec. 2019

SCIENTIFIC PROGRAMME

09.45
Opening and welcome
Jochen Lange, St.Gallen, CH

10.00
Pathophysiology and non-operative management of symptomatic uncomplicated diverticular disease
Robin Spiller, Nottingham, UK

10.30
Surgery of acute diverticulitis – evidence, eminence and real life
Willem Bemelman, Amsterdam, NL

11.00
Management of atypical diverticulitis
Dieter Hahnloser, Lausanne, CH

11.30
Hartmann reversal: open, laparoscopic or transanal?
Roel Hompes, Amsterdam, NL

13.30
The surgeon personality – influence on decision making, risk-taking and outcomes
Desmond Winter, Dublin, IE

14.00
SATELLITE SYMPOSIUM Medtronic

15.00
Clinical applications of image-guided cancer surgery
Cornelis van de Velde, Leiden, NL

16.00
Volvulus of the colon – a treatment algorithm
Peter Sagar, Leeds, UK

16.30
Hereditary colorectal cancer syndromes: tailored surgical treatment
Gabriela Möslein, Wuppertal, DE

17.00
Lars Pahlman and Herand Abcarian (2015)
Herand Abcarian, Chicago, US



17.20
Lars Pahlman Lecture
Steven Wexner, Weston, US

Tuesday, 3 Dec. 2019

09.00
Robotic-assisted versus conventional laparoscopic surgery for rectal cancer
Amjad Parvaiz, Poole, UK

09.30
Robotic multivisceral resection
Paris Tekkis, London, UK

10.00
SATELLITE SYMPOSIUM Karl Storz

11.30
Neoadjuvant chemotherapy for advanced colon cancer: clinical and pathological Results
Dion Morton, Birmingham, UK
Philip Quirke, Leeds, UK

12.30
Cytoreductive surgery and hyperthermic intraoperative chemotherapy for intestinal and ovarian cancers: lessons learned from 2 decades of clinical trials
Vic Verwaal, Aarhus, DK

14.30
Mechanical bowel obstruction: rush to the OR or stent and dine
Neil Mortensen, Oxford, UK

15.00
Controversies in IBD surgery
André d'Hoore, Leuven, BE

16.00
How to deal with IBD and dysplasia
Janindra Warusavitarne, London, UK

16.30
Perianal Crohn – avoiding delay and best surgical practice
Justin Davies, Cambridge, UK

17.00
Perianal Crohn – stem cells therapy and current medical approach
Gerhard Rogler, Zürich, CH

Wednesday, 4 Dec. 2019

09.00
Is anastomotic leak an infectious disease
Ronan O'Connell, Dublin, IE

09.30
Is it time to invest in robotic surgery?
Antonino Spinelli, Milan, IT

10.00
SATELLITE SYMPOSIUM Intuitive

11.00
New developments in robotic systems
Alberto Arezzo, Torino, IT

12.00
Posterior component separation for abdominal wall reconstruction: evolution from open to minimal invasive using the robotic platform
Filip Muysoms, Gent, BE

14.00
Coloproctology 4.0 – the networked surgeon
Richard Brady, Newcastle upon Tyne, UK

14.30
SATELLITE SYMPOSIUM Olympus

15.30
The elderly colorectal patient – functional outcomes and patient reported outcomes
Isacco Montroni, Faenza, IT

16.30
The microbiome and colorectal cancer
Philip Quirke, Leeds, UK

17.00
Surgical management of rectal endometriosis
Eric Rullier, Bordeaux, FR



17.30
EAES Presidential Lecture 3D printing for the general surgeon
Andrea Pietrabissa, Pavia, IT

Thursday, 5 Dec. 2019

09.00
Management of locoregionally advanced colon cancer
Torbjörn Holm, Stockholm, SE

09.30
ROUNDTABLE
Herand Abcarian, Chicago, US
Bill Heald, Basingstoke, UK

10.30
Artificial intelligence in colorectal surgery
Michele Diana, Strasbourg, FR

11.30
The mesentery in colonic diseases
Calvin Coffey, Luimneach, IE

12.00
Technical pearls and typical mistakes in minimal invasive colectomy
Antonio Lacy, Barcelona, ES

12.30
Choosing the right anastomotic technique in colon surgery
Roberto Persiani, Rom, IT

13.00
Precision surgery: past, present and future
Brendan Moran, Basingstoke, UK

13.30
Poster award
Michel Adamina, Winterthur, CH

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The impact of conversion on the risk of major complication following laparoscopic colonic surgery: an international, multicentre prospective audit

The 2017 and 2015 European Society of Coloproctology (ESCP) collaborating groups

European Society of Coloproctology (ESCP) Cohort Studies Committee, Department of Colorectal Surgery, University of Birmingham, Birmingham, UK

Received 30 May 2018; accepted 6 August 2018

Abstract

Background Laparoscopy has now been implemented as a standard of care for elective colonic resection around the world. During the adoption period, studies showed that conversion may be detrimental to patients, with poorer outcomes than both laparoscopic completed or planned open surgery. The primary aim of this study was to determine whether laparoscopic conversion was associated with a higher major complication rate than planned open surgery in contemporary, international practice.

Methods Combined analysis of the European Society of Coloproctology 2017 and 2015 audits. Patients were included if they underwent elective resection of a colonic segment from the caecum to the rectosigmoid junction with primary anastomosis. The primary outcome measure was the 30-day major complication rate, defined as Clavien-Dindo grade III-V.

Results Of 3980 patients, 64% (2561/3980) underwent laparoscopic surgery and a laparoscopic conversion rate of 14% (359/2561). The major complication rate was highest after open surgery (laparoscopic 7.4%, converted 9.7%, open 11.6%, $P < 0.001$). After case mix adjustment in a multilevel model, only planned open

(and not laparoscopic converted) surgery was associated with increased major complications in comparison to laparoscopic surgery (OR 1.64, 1.27–2.11, $P < 0.001$).

Conclusions Appropriate laparoscopic conversion should not be considered a treatment failure in modern practice. Conversion does not appear to place patients at increased risk of complications *vs* planned open surgery, supporting broadening of selection criteria for attempted laparoscopy in elective colonic resection.

Keywords Colon cancer, rectal cancer, gastrointestinal surgery, laparoscopic surgery, surgery

What does this paper add to the literature?

In modern international practice, 64% of elective colonic resections are started laparoscopically and 14.7% are converted to open. Laparoscopic conversion does not place patients at increased risk of complications when compared to planned open surgery, suggesting colorectal surgeons select patients appropriately for laparoscopic surgery and can convert appropriately. This supports laparoscopy as the primary approach for colonic resection in modern post-implementation practice.

Introduction

Minimally invasive approaches for colonic resection are now incorporated into clinical practice in many settings [1]. A number of major international randomised trials (COST, CLASSICC, COLOR I, ALCCaS) have described the safety, feasibility and benefits of laparoscopic segmental resection including reduced

intraoperative blood loss, faster return of bowel function and reduced length of stay, without compromise to oncological outcomes [2–7].

Published studies in the initial period of adoption of laparoscopy suggested that patients who undergo conversion from laparoscopic to open surgery had more short-term infections complications (although oncologically equitable resections) than procedures completed laparoscopically, or those who had planned open surgery [5,8–10]. Since many units have now overcome unit-level learning curves, performance may have changed in terms of indications for conversion, rate of conversion and outcomes when conversion occurs. Following the IDEAL framework for surgical

Correspondence to: Mr Aneel Bhangu, European Society of Coloproctology (ESCP) Cohort Studies Committee, Department of Colorectal Surgery, University of Birmingham, Heritage Building, Mindelsohn Way, Birmingham, B15 2TH UK.
E-mail: a.a.bhangu@bham.ac.uk

innovation, up-to-date, multicentre ‘surveillance’ is required to assess the safety and penetrance of laparoscopic colonic resection in contemporary practice (IDEAL stage 4), and to support further roll-out of laparoscopic surgery for novel indications and into new settings.

The primary aim of this study was to determine whether laparoscopic conversion was associated with a higher major complication rate than planned open surgery. Our hypothesis was that after adjusted for case-mix, laparoscopic conversion may have a favourable complication profile to primary open surgery within modern post-implementation practice.

Methods

Protocol and centres

This study combines patients from the 2015 ESCP right hemicolectomy audit and the 2017 ESCP left-sided colorectal resection audit, conducted according to pre-specified protocols (<http://www.escp.eu.com/research/c-ohort-studies>). Any unit performing elective gastrointestinal surgery was eligible to register to enter patients into the study. No minimum case volume, or centre-specific limitations were specified. Study protocols were disseminated to registered members of the European Society of Coloproctology (ESCP), and through national surgical and colorectal societies, including the European Crohn’s and Colitis Organisation.

Patient eligibility

Patients included in this pre-planned analysis were adults (≥ 16 years) undergoing elective segmental colectomy from the caecum to the rectosigmoid colon with a single, primary anastomosis. Open, laparoscopic, and laparoscopic-converted procedures were all included. Patients having robotic or robotic-converted procedures were excluded. Operations with multiple (> 1) anastomoses were excluded, as were resections including the rectum, those with formation of end colostomy without restoration of gastrointestinal continuity (e.g. Hartmann’s procedure) or multivisceral resections. Patients undergoing more extensive resection such as subtotal colectomy or panproctocolectomy were excluded. Both operations for malignant and benign indications were eligible.

Data capture

For right-sided colonic resections, patients were captured over a 6-week period between 15 January 2015 and 15 April 2015. For left-sided colonic resections,

patients were included over an 8 week period between 1 February 2017 and 10 May 2017. Teams of up to five surgeons and surgical trainees worked collaboratively to collect prospective data on all consecutive eligible patients at each centre. All teams included at least one consultant or attending-level surgeon to quality assure data collection. Data was entered contemporaneously on to a secure, user-encrypted online platform (NetSolving and REDCap for 2015 and 2017 audits respectively) without using patient identifiable information. Centres were asked to validate that all eligible patients during the study period had been entered, and to attain $> 95\%$ completeness of data field entry prior to final submission. Laparoscopic conversion was described as unplanned extension of the primary laparotomy incision, or a secondary laparotomy incision, created intraoperatively for any purpose other than specimen extraction or exteriorization (i.e. to form an anastomosis).

Outcome measure

The primary outcome measure was the postoperative major complication rate, defined as Clavien-Dindo classification grade 3–5 (reoperation, reintervention, unplanned admission to critical care, organ support requirement or death). The secondary outcome measures were (1) overall anastomotic leak, pre-defined as either (i) gross anastomotic leakage proven radiologically or clinically, or (ii) the presence of an intraperitoneal (abdominal or pelvic) fluid collection on postoperative imaging.

Statistical analysis

This report has been prepared in accordance to guidelines set by the STROBE (strengthening the reporting of observational studies in epidemiology) [11] statement for observational studies. Patient, disease and operative characteristics were compared using Student’s *t*-test for normal, continuous data, Mann-Whitney *U* test for non-normal continuous data or Chi-squared test for categorical data. To test the association between the major complications and the main explanatory variables of interest (laparoscopic completed, laparoscopic converted, and open surgery), a mixed-effects logistic regression model was fitted. Clinically plausible patient, disease and operation-specific factors were entered into the model for risk-adjustment, treated as fixed effects. These were defined *a priori* within the study protocol and included irrespective of their significance on univariate analysis. The treating hospital were entered into the model as a random-effect, to adjust for hospital-level variation in

outcome. Similar models were created to assess associations with the secondary outcome measures (anastomotic leak and laparoscopic conversion). Effect estimates are presented as odds ratios (OR) with 95% confidence intervals (95% CI) and two-tailed *P*-values. An alpha level of 0.05 was used throughout. Data analysis was undertaken using R STUDIO V3.1.1 (R Foundation, Boston, Massachusetts, USA).

Ethical approval

All participating centres were responsible for compliance to local approval requirements for ethics approval or indemnity as required. In the UK, the National Research Ethics Service tool recommended that this project was not classified as research, and the protocol was registered as clinical audit in all participating centres.

Results

Patients and centres

In this study, 3980 patients, from 566 centres across 48 countries underwent an elective colonic resection (Fig. 1). 1419 (36%) received planned open surgery and 2561 (64%) had their procedures started laparoscopically. Of these laparoscopic operations, 359 required conversion to open surgery, resulting in a conversion rate of 14.7% (Fig. 2).

Compared to those who underwent a planned open resection, laparoscopic converted patients were older (converted *vs* open; 35.9% *vs* 29.7% aged 70–80 years), more likely to be male (60.7% *vs* 51.1%), have a low ASA grade (65.2% *vs* 56.0%), be obese (26.5% *vs* 20.2%) and were less likely to have a history of ischaemic heart disease/cerebrovascular accident (15.9% *vs* 21.7%).

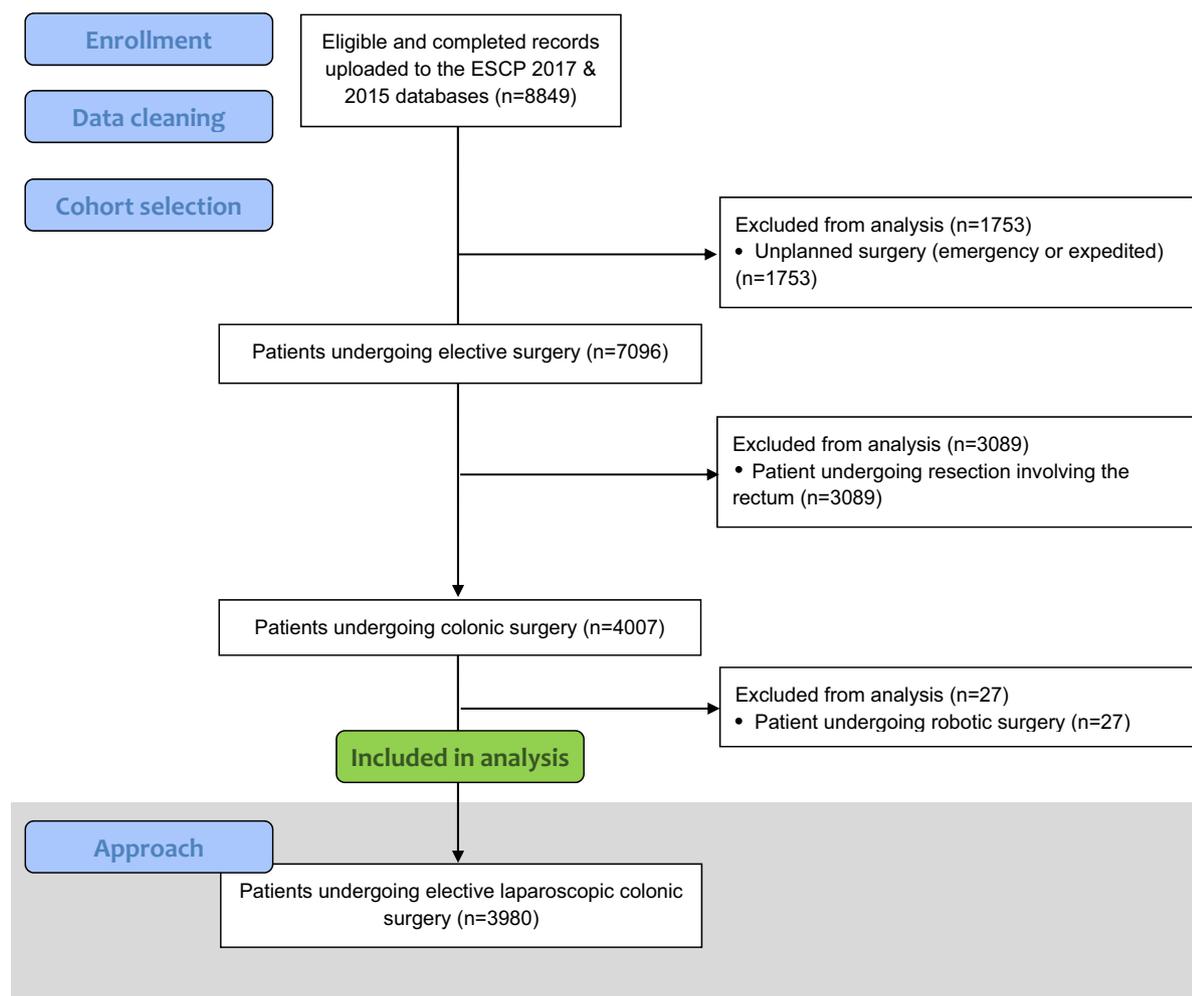


Figure 1 Flowchart for patients included in the analysis of elective, laparoscopic colonic surgery.

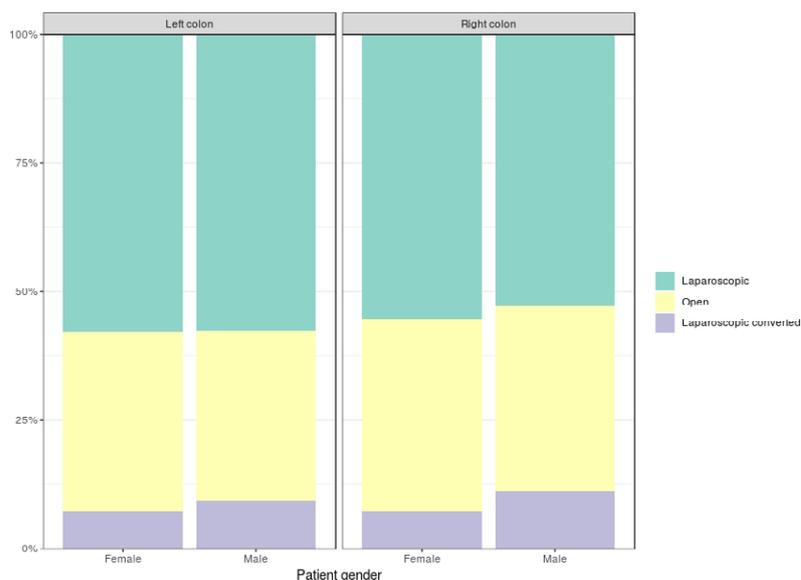


Figure 2 Selection of operative approach by patient gender and location of resection.

Compared to those who underwent a completed laparoscopic resection, patients that required a laparoscopic conversion were older (converted *vs* laparoscopic; 16.7% *vs* 14.2% aged > 80 years), more likely to be male (60.7% *vs* 51.5%), have a high ASA grade (ASA 3 to 5; 34.5% *vs* 27.3%) and be obese (26.5% *vs* 21.3%; Table 1).

Table 1 Patient and disease characteristics of patients undergoing segmental colonic resection by approach.

| Factor | Levels | Open | Laparoscopic converted | <i>P</i> -value | Laparoscopic | Laparoscopic converted | <i>P</i> -value |
|------------------------------|---------------------------|-------------|------------------------|-----------------|--------------|------------------------|-----------------|
| Age | < 55 | 227 (16.0) | 60 (16.7) | 0.032 | 450 (88.2) | 60 (11.8) | 0.001 |
| | 55–70 | 497 (35.0) | 109 (30.4) | | 807 (88.1) | 109 (11.9) | |
| | 70–80 | 421 (29.7) | 129 (35.9) | | 633 (83.1) | 129 (16.9) | |
| | > 80 | 274 (19.3) | 60 (16.7) | | 312 (83.9) | 60 (16.1) | |
| Gender | Female | 694 (48.9) | 141 (39.3) | 0.001 | 1067 (88.3) | 141 (11.7) | 0.001 |
| | Male | 725 (51.1) | 218 (60.7) | | 1135 (83.9) | 218 (16.1) | |
| ASA class | Low risk (ASA 1–2) | 794 (56.0) | 234 (65.2) | 0.006 | 1596 (87.2) | 234 (12.8) | 0.017 |
| | High risk (ASA 3–5) | 622 (43.8) | 124 (34.5) | | 602 (82.9) | 124 (17.1) | |
| BMI | Normal weight | 511 (36.0) | 104 (29.0) | 0.047 | 745 (87.8) | 104 (12.2) | 0.032 |
| | Underweight | 59 (4.2) | 13 (3.6) | | 44 (77.2) | 13 (22.8) | |
| | Overweight | 498 (35.1) | 131 (36.5) | | 820 (86.2) | 131 (13.8) | |
| | Obese | 287 (20.2) | 95 (26.5) | | 468 (83.1) | 95 (16.9) | |
| History of IHD/CVA | No | 1111 (78.3) | 302 (84.1) | 0.015 | 1835 (85.9) | 302 (14.1) | 0.709 |
| | Yes | 308 (21.7) | 57 (15.9) | | 367 (86.6) | 57 (13.4) | |
| History of diabetes mellitus | No | 1183 (83.4) | 301 (83.8) | 0.345 | 1871 (86.1) | 301 (13.9) | 0.748 |
| | Diet or tablet controlled | 115 (8.1) | 36 (10.0) | | 184 (83.6) | 36 (16.4) | |
| | Insulin controlled | 37 (2.6) | 7 (1.9) | | 44 (86.3) | 7 (13.7) | |
| | Diabetes: any control | 84 (5.9) | 15 (4.2) | | 103 (87.3) | 15 (12.7) | |
| Smoking history | Non-smoker | 1187 (83.7) | 291 (81.1) | 0.392 | 1822 (86.2) | 291 (13.8) | 0.413 |
| | Current | 183 (12.9) | 51 (14.2) | | 261 (83.7) | 51 (16.3) | |
| Indication | Benign | 250 (17.6) | 68 (18.9) | 0.559 | 472 (87.4) | 68 (12.6) | 0.283 |
| | Malignant | 1169 (82.4) | 291 (81.1) | | 1730 (85.6) | 291 (14.4) | |
| Resection location | Left colon | 465 (32.8) | 116 (32.3) | 0.869 | 790 (87.2) | 116 (12.8) | 0.19 |
| | Right colon | 954 (67.2) | 243 (67.7) | | 1412 (85.3) | 243 (14.7) | |

P-value derived from χ^2 test for categorical variables. % shown by row.

SD, Standard deviation; IQR, Interquartile range; IHD, Ischemic heart disease; CVA, Cerebrovascular accident; N/A, Not applicable.

Unadjusted postoperative outcomes

Completed laparoscopic surgery was associated with low rates of major postoperative complications, anastomotic leaks and re-operation (Table 2). When comparing the unadjusted postoperative outcomes between laparoscopic converted and open surgeries, there were no significant differences in major postoperative complications (9.7% *vs* 11.6%), re-operation (8.1% *vs* 6.8%), or anastomotic leak (9.5% *vs* 8.4%) rates between the groups.

Adjusted postoperative outcomes

The major complication rate was highest after open surgery (laparoscopic 7.4%, converted 9.7%, open 11.6%, $P < 0.001$). After adjustment for confounding factors, in comparison to completed laparoscopic surgery, open surgery was associated with increased major postoperative complications (OR 1.64, 1.27–2.11, $P < 0.001$) but laparoscopic converted surgery was not (OR 1.24, 0.83–1.87, $P = 0.30$; Table 3). The anastomotic leak rate was highest after converted surgery (5.4%, 9.5%, 8.4% respectively, $P < 0.001$). In the multilevel model, laparoscopic converted surgery (OR 2.07, 1.34–3.21, $P = 0.001$) and open surgery (OR 1.87, 1.37–2.56, $P < 0.001$) had similar higher risks of leak compared to completed laparoscopic surgery (Table 4).

Predicting laparoscopic conversion to open surgery

In the multivariable analysis, independent predictors of laparoscopic conversion were (Table 5):

- 1 Age ≥ 70 years (age 71–80, OR 1.55, 1.03–2.32, $P = 0.04$; age > 80 , OR 1.62, 1.00–2.61, $P = 0.05$)
- 2 Male gender (OR 1.50, 1.17–1.93, $P = 0.001$)
- 3 ASA grade 3–5 (OR 1.43, 1.07–1.92, $P = 0.02$)

- 4 Low BMI (Underweight, OR 2.37, 1.18–4.75, $P = 0.02$)

Patients with a history of ischaemic heart disease or cerebrovascular accident were less likely to have a conversion (OR 0.65, 0.45–0.93, $P = 0.02$).

Discussion

This study showed that laparoscopic converted colonic resection was not associated with increased major complications compared to laparoscopic completed surgery, or with increased anastomotic leaks compared to open surgery. This supports laparoscopic resection as the primary approach when colonic resection is indicated. It suggests that following widespread implementation of laparoscopic surgery over the last two decades, as surgical experience has increased colorectal surgeons are now able to better select patients for both a complete laparoscopic operation, and judge intraoperatively to convert to an open procedure (Fig. 3).

In this multicentre international study, two thirds of patients underwent a planned laparoscopic operation. This is one of the highest rates described worldwide showing the high implementation of laparoscopic approach in contemporary practice [12]. This study did not collect data on previous surgery or size or stage of lesion resection, which may have indicated that an open operation in the first instance was entirely appropriate. We also have not included robotic surgical approaches in this analysis which may underestimate the overall minimally invasive surgery rate. However, our data provides scope to increase the laparoscopic rate in units or areas where it has not yet been implemented (including those in low and middle-income settings).

Table 2 Outcomes of patients undergoing segmental colonic resection by approach.

| Factor | Levels | Open | Laparoscopic converted | <i>P</i> -value | Laparoscopic | Laparoscopic converted | <i>P</i> -value |
|-----------------------------|-----------------------|-------------|------------------------|-----------------|--------------|------------------------|-----------------|
| Post-operative complication | No major complication | 1220 (86.0) | 318 (88.6) | 0.408 | 2009 (91.2) | 318 (88.6) | 0.261 |
| | Major complication | 165 (11.6) | 35 (9.7) | | 162 (7.4) | 35 (9.7) | |
| | Missing | 34 (2.4) | 6 (1.7) | | 31 (1.4) | 6 (1.7) | |
| Leak | No leak | 1221 (86.0) | 312 (86.9) | 0.285 | 2047 (93.0) | 312 (86.9) | < 0.001 |
| | Leak | 119 (8.4) | 34 (9.5) | | 118 (5.4) | 34 (9.5) | |
| Re-operation | No | 1323 (93.2) | 330 (91.9) | 0.385 | 2079 (94.4) | 330 (91.9) | 0.064 |
| | Yes | 96 (6.8) | 29 (8.1) | | 123 (5.6) | 29 (8.1) | |
| Length of stay | Mean (SD) | 10.2 (6.1) | 8.8 (5.8) | < 0.001 | 7.1 (5) | 8.8 (5.8) | < 0.001 |

Major postoperative complications were pre-defined as Clavien-Dindo grade complications 3 to 5 (re-operation, re-intervention, admission to critical care or death) P -values derived from χ^2 test for categorical variables and Student's T -test for parametric continuous variables, % shown by column.

Table 3 Univariable and multilevel models for major postoperative complications following colonic surgery.

| Factor | Levels | No major complication | Major complication | OR (univariable) | OR (multilevel) |
|-----------------------------------|---------------------------|-----------------------|--------------------|--------------------------------|--------------------------------|
| Approach | Laparoscopic | 1827 (56.1) | 145 (44.2) | – (Reference) | – (Reference) |
| | Open | 1134 (34.8) | 151 (46.0) | 1.68 (1.32–2.13, $P < 0.001$) | 1.64 (1.27–2.11, $P < 0.001$) |
| | Laparoscopic converted | 293 (9.0) | 32 (9.8) | 1.38 (0.91–2.03, $P = 0.120$) | 1.24 (0.83–1.87, $P = 0.297$) |
| Age | < 55 | 619 (19.0) | 49 (14.9) | – | – |
| | 55–70 | 1179 (36.2) | 108 (32.9) | 1.16 (0.82–1.66, $P = 0.415$) | 1.00 (0.68–1.48, $P = 0.995$) |
| | 70–80 | 960 (29.5) | 101 (30.8) | 1.33 (0.94–1.91, $P = 0.117$) | 1.09 (0.72–1.65, $P = 0.676$) |
| | > 80 | 496 (15.2) | 70 (21.3) | 1.78 (1.22–2.63, $P = 0.003$) | 1.34 (0.85–2.12, $P = 0.211$) |
| Gender | Female | 1593 (49.0) | 130 (39.6) | – | – |
| | Male | 1661 (51.0) | 198 (60.4) | 1.46 (1.16–1.84, $P = 0.001$) | 1.38 (1.09–1.76, $P = 0.008$) |
| ASA class | Low risk (ASA 1–2) | 2208 (67.9) | 179 (54.6) | – | – |
| | High risk (ASA 3–5) | 1046 (32.1) | 149 (45.4) | 1.76 (1.40–2.21, $P < 0.001$) | 1.46 (1.12–1.92, $P = 0.005$) |
| BMI | Normal weight | 1177 (36.2) | 115 (35.1) | – | – |
| | Underweight | 99 (3.0) | 10 (3.0) | 1.03 (0.49–1.94, $P = 0.923$) | 1.05 (0.53–2.10, $P = 0.884$) |
| | Overweight | 1255 (38.6) | 120 (36.6) | 0.98 (0.75–1.28, $P = 0.874$) | 0.92 (0.70–1.22, $P = 0.576$) |
| | Obese | 723 (22.2) | 83 (25.3) | 1.17 (0.87–1.58, $P = 0.288$) | 1.06 (0.78–1.46, $P = 0.704$) |
| History of IHD/CVA | No | 2690 (82.7) | 245 (74.7) | – | – |
| | Yes | 564 (17.3) | 83 (25.3) | 1.62 (1.23–2.10, $P < 0.001$) | 1.29 (0.95–1.75, $P = 0.097$) |
| History of diabetes mellitus | No | 2755 (84.7) | 265 (80.8) | – | – |
| | Diet or tablet controlled | 270 (8.3) | 30 (9.1) | 1.16 (0.76–1.69, $P = 0.477$) | 1.00 (0.66–1.53, $P = 0.991$) |
| | Insulin controlled | 62 (1.9) | 11 (3.4) | 1.84 (0.91–3.41, $P = 0.066$) | 1.34 (0.68–2.64, $P = 0.403$) |
| | Diabetes: any control | 167 (5.1) | 22 (6.7) | 1.37 (0.84–2.13, $P = 0.182$) | 1.02 (0.61–1.69, $P = 0.946$) |
| Anticoagulant or antiplatelet use | No | 997 (30.6) | 99 (30.2) | – | – |
| | Yes | 185 (5.7) | 25 (7.6) | 1.36 (0.84–2.14, $P = 0.195$) | 0.98 (0.60–1.61, $P = 0.934$) |
| | Not collected | 2072 (63.7) | 204 (62.2) | 0.99 (0.77–1.28, $P = 0.947$) | 0.87 (0.65–1.17, $P = 0.357$) |
| Smoking history | Non-smoker | 2842 (87.3) | 274 (83.5) | – | – |
| | Current | 412 (12.7) | 54 (16.5) | 1.36 (0.99–1.84, $P = 0.052$) | 1.41 (1.02–1.94, $P = 0.039$) |
| Indication | Benign | 660 (20.3) | 60 (18.3) | – | – |
| | Malignant | 2594 (79.7) | 268 (81.7) | 1.14 (0.85–1.54, $P = 0.392$) | 0.97 (0.69–1.36, $P = 0.839$) |
| Resection location | Left colon | 1182 (36.3) | 124 (37.8) | – | – |
| | Right colon | 2072 (63.7) | 204 (62.2) | 0.94 (0.74–1.19, $P = 0.596$) | – |

Major postoperative complications were pre-defined as Clavien-Dindo grade complications 3 to 5 (re-operation, re-intervention, admission to critical care or death). Odds ratio (OR) presented with 95% confidence intervals. % shown by column.

SD, Standard deviation; IQR, Interquartile range; IHD, Ischemic heart disease; CVA, Cerebrovascular accident; N/A, Not applicable.

The conversion rate was 14%, consistent with a decreasing trend since the introduction of laparoscopic surgery. In 2005, the CLASICC trial showed a laparoscopic conversion rate of 29.0% [3]. Subsequently, several studies showed conversion rates between 10.4 and 29.0% with detrimental outcome [3,4,13–15]. More recently, a Dutch national review reported a conversion rate of 8.6% for colon cancer [13]. The literature has been divided about whether conversion impacts detrimentally on short-term outcomes. Dutch series have reported higher rates of postoperative complications in patients who had laparoscopic conversion when compared to open resections. These rates were significantly

higher in those with late conversion (> 30 min) compared to early conversion (OR 1.34, 1.05–1.72). There was no impact of conversion on mortality in these patients [13]. In contrast, one of the largest series of segmental resections reported, with 207 311 patients operated in the United States, found that conversion had a higher morbidity and mortality than completed laparoscopic procedures, but better outcomes than primary open procedures [16]. Allaix *et al.* showed no significant differences in short-term postoperative morbidity, mortality, or hospital stay between converted and laparoscopic completed group in a cohort of 1114 patients [5]. The present prospective multicentre study

Table 4 Univariable and multilevel models for anastomotic leak amongst patients undergoing colonic surgery with anastomosis only.

| Factor | Levels | No leak | Leak | OR (univariable) | OR (multilevel) |
|-----------------------------------|---------------------------|-------------|------------|------------------------------------|------------------------------------|
| Approach | Laparoscopic | 1839 (56.8) | 98 (43.8) | – (<i>Reference</i>) | – (<i>Reference</i>) |
| | Open | 1114 (34.4) | 96 (42.9) | 1.62 (1.21–2.16, <i>P</i> = 0.001) | 1.87 (1.37–2.56, <i>P</i> < 0.001) |
| | Laparoscopic converted | 285 (8.8) | 30 (13.4) | 1.98 (1.27–2.99, <i>P</i> = 0.002) | 2.07 (1.34–3.21, <i>P</i> = 0.001) |
| Age | < 55 | 599 (18.5) | 44 (19.6) | – | – |
| | 55–70 | 1174 (36.3) | 84 (37.5) | 0.97 (0.67–1.43, <i>P</i> = 0.892) | 0.94 (0.61–1.43, <i>P</i> = 0.756) |
| | 70–80 | 967 (29.9) | 60 (26.8) | 0.84 (0.57–1.27, <i>P</i> = 0.411) | 0.79 (0.49–1.26, <i>P</i> = 0.313) |
| | > 80 | 498 (15.4) | 36 (16.1) | 0.98 (0.62–1.55, <i>P</i> = 0.945) | 0.86 (0.50–1.48, <i>P</i> = 0.583) |
| Gender | Female | 1570 (48.5) | 90 (40.2) | – | – |
| | Male | 1668 (51.5) | 134 (59.8) | 1.40 (1.07–1.85, <i>P</i> = 0.016) | 1.28 (0.96–1.71, <i>P</i> = 0.089) |
| ASA class | Low risk (ASA 1–2) | 2183 (67.4) | 144 (64.3) | – | – |
| | High risk (ASA 3–5) | 1055 (32.6) | 80 (35.7) | 1.15 (0.86–1.52, <i>P</i> = 0.334) | 1.03 (0.74–1.44, <i>P</i> = 0.844) |
| BMI | Normal weight | 1164 (35.9) | 76 (33.9) | – | – |
| | Underweight | 96 (3.0) | 6 (2.7) | 0.96 (0.36–2.08, <i>P</i> = 0.920) | 0.90 (0.38–2.16, <i>P</i> = 0.819) |
| | Overweight | 1254 (38.7) | 86 (38.4) | 1.05 (0.76–1.45, <i>P</i> = 0.763) | 1.00 (0.72–1.39, <i>P</i> = 0.994) |
| | Obese | 724 (22.4) | 56 (25.0) | 1.18 (0.83–1.69, <i>P</i> = 0.353) | 1.05 (0.72–1.53, <i>P</i> = 0.812) |
| History of IHD/CVA | No | 2660 (82.1) | 177 (79.0) | – | – |
| | Yes | 578 (17.9) | 47 (21.0) | 1.22 (0.87–1.69, <i>P</i> = 0.239) | 1.14 (0.77–1.67, <i>P</i> = 0.514) |
| History of diabetes mellitus | No | 2743 (84.7) | 181 (80.8) | – | – |
| | Diet or tablet controlled | 273 (8.4) | 22 (9.8) | 1.22 (0.75–1.89, <i>P</i> = 0.394) | 1.33 (0.81–2.19, <i>P</i> = 0.256) |
| | Insulin controlled | 64 (2.0) | 7 (3.1) | 1.66 (0.68–3.43, <i>P</i> = 0.213) | 1.63 (0.71–3.73, <i>P</i> = 0.251) |
| Diabetes: any control | Diabetes: | 158 (4.9) | 14 (6.2) | 1.34 (0.73–2.29, <i>P</i> = 0.308) | 0.94 (0.51–1.74, <i>P</i> = 0.841) |
| | – | – | – | – | – |
| Anticoagulant or antiplatelet use | No | 965 (29.8) | 67 (29.9) | – | – |
| | Yes | 175 (5.4) | 22 (9.8) | 1.81 (1.07–2.96, <i>P</i> = 0.022) | 1.84 (1.06–3.20, <i>P</i> = 0.031) |
| | Not collected | 2098 (64.8) | 135 (60.3) | 0.93 (0.69–1.26, <i>P</i> = 0.622) | 1.25 (0.67–2.33, <i>P</i> = 0.481) |
| Smoking history | Non-smoker | 2818 (87.0) | 187 (83.5) | – | – |
| | Current | 420 (13.0) | 37 (16.5) | 1.33 (0.91–1.89, <i>P</i> = 0.131) | 1.22 (0.83–1.78, <i>P</i> = 0.310) |
| Indication | Benign | 616 (19.0) | 51 (22.8) | – | – |
| | Malignant | 2622 (81.0) | 173 (77.2) | 0.80 (0.58–1.11, <i>P</i> = 0.170) | 0.81 (0.55–1.19, <i>P</i> = 0.288) |
| Resection location | Left colon | 1140 (35.2) | 89 (39.7) | – | – |
| | Right colon | 2098 (64.8) | 135 (60.3) | 0.82 (0.63–1.09, <i>P</i> = 0.172) | – |
| Anastomotic configuration | End to End | 808 (25.0) | 68 (30.4) | – | – |
| | Side to Side | 1359 (42.0) | 100 (44.6) | 0.87 (0.64–1.21, <i>P</i> = 0.411) | 0.70 (0.38–1.28, <i>P</i> = 0.249) |
| | Side to End | 147 (4.5) | 7 (3.1) | 0.57 (0.23–1.17, <i>P</i> = 0.162) | 0.43 (0.19–0.97, <i>P</i> = 0.043) |
| | End to Side | 134 (4.1) | 4 (1.8) | 0.35 (0.11–0.87, <i>P</i> = 0.047) | 0.25 (0.08–0.82, <i>P</i> = 0.023) |
| Defunctioning stoma | Yes | 46 (1.4) | 5 (2.2) | – | – |
| | No | 3192 (98.6) | 219 (97.8) | 0.63 (0.27–1.83, <i>P</i> = 0.334) | 0.80 (0.31–2.10, <i>P</i> = 0.654) |

Overall anastomotic leak was pre-defined as either i) gross anastomotic leakage proven radiologically or clinically, or ii) the presence of an intraperitoneal (abdominal or pelvic) fluid collection on post-operative imaging. Odds ratio (OR) presented with 95% confidence intervals. % shown by column.

SD, Standard deviation; IQR, Interquartile range; IHD, Ischemic heart disease; CVA, Cerebrovascular accident; N/A, Not applicable.

validates the findings of these retrospective analyses in a modern, real-world cohort, demonstrating that conversion does not place patients at increased risk of major complications, nor does it alter the baseline risk of leak to that of open surgery. This is likely to reflect satisfactory patient selection for both the initial laparoscopic

procedure and conversion to open surgery; however, we did not collect specific information on early vs later conversions, or the indication for conversion in this study.

Our data demonstrates that male gender, older age, low BMI and higher ASA grade are all associated with a higher risk of laparoscopic conversion. The factors

Table 5 Factors associated with laparoscopic completion amongst patients undergoing attempted laparoscopic colonic surgery.

| Factor | Levels | Minimally invasive completion | Conversion | OR (univariable) | OR (multilevel) |
|-----------------------------------|---------------------------|-------------------------------|------------|------------------------------------|------------------------------------|
| Age | < 55 | 414 (21.0) | 56 (17.2) | – | – |
| | 55–70 | 727 (36.9) | 101 (31.1) | 1.03 (0.73–1.46, <i>P</i> = 0.880) | 1.06 (0.72–1.56, <i>P</i> = 0.773) |
| | 70–80 | 561 (28.4) | 113 (34.8) | 1.49 (1.06–2.11, <i>P</i> = 0.024) | 1.55 (1.03–2.32, <i>P</i> = 0.036) |
| | > 80 | 270 (13.7) | 55 (16.9) | 1.51 (1.01–2.25, <i>P</i> = 0.046) | 1.62 (1.00–2.61, <i>P</i> = 0.049) |
| Gender | Female | 961 (48.7) | 129 (39.7) | – | – |
| | Male | 1011 (51.3) | 196 (60.3) | 1.44 (1.14–1.84, <i>P</i> = 0.003) | 1.50 (1.17–1.93, <i>P</i> = 0.001) |
| ASA class | Low risk (ASA 1–2) | 1450 (73.5) | 213 (65.5) | – | – |
| | High risk (ASA 3–5) | 522 (26.5) | 112 (34.5) | 1.46 (1.14–1.87, <i>P</i> = 0.003) | 1.43 (1.07–1.92, <i>P</i> = 0.015) |
| BMI | Normal weight | 706 (35.8) | 98 (30.2) | – | – |
| | Underweight | 41 (2.1) | 12 (3.7) | 2.11 (1.03–4.03, <i>P</i> = 0.031) | 2.37 (1.18–4.75, <i>P</i> = 0.015) |
| | Overweight | 781 (39.6) | 127 (39.1) | 1.17 (0.88–1.56, <i>P</i> = 0.272) | 1.10 (0.82–1.48, <i>P</i> = 0.529) |
| | Obese | 444 (22.5) | 88 (27.1) | 1.43 (1.04–1.95, <i>P</i> = 0.025) | 1.33 (0.95–1.85, <i>P</i> = 0.093) |
| History of IHD/CVA | No | 1649 (83.6) | 277 (85.2) | – | – |
| | Yes | 323 (16.4) | 48 (14.8) | 0.88 (0.63–1.22, <i>P</i> = 0.465) | 0.65 (0.45–0.93, <i>P</i> = 0.020) |
| History of diabetes mellitus | No | 1684 (85.4) | 272 (83.7) | – | – |
| | Diet or tablet controlled | 161 (8.2) | 32 (9.8) | 1.23 (0.81–1.81, <i>P</i> = 0.310) | 1.00 (0.65–1.54, <i>P</i> = 0.991) |
| | Insulin controlled | 33 (1.7) | 6 (1.8) | 1.13 (0.42–2.53, <i>P</i> = 0.792) | 0.88 (0.35–2.19, <i>P</i> = 0.785) |
| | Diabetes: any control | 94 (4.8) | 15 (4.6) | 0.99 (0.54–1.68, <i>P</i> = 0.966) | 0.91 (0.50–1.68, <i>P</i> = 0.774) |
| Anticoagulant or antiplatelet use | No | 640 (32.5) | 98 (30.2) | – | – |
| | Yes | 110 (5.6) | 14 (4.3) | 0.83 (0.44–1.46, <i>P</i> = 0.543) | 0.78 (0.42–1.47, <i>P</i> = 0.445) |
| | Not collected | 1222 (62.0) | 213 (65.5) | 1.14 (0.88–1.48, <i>P</i> = 0.324) | 1.12 (0.83–1.51, <i>P</i> = 0.443) |
| Smoking history | Non-smoker | 1729 (87.7) | 275 (84.6) | – | – |
| | Current | 243 (12.3) | 50 (15.4) | 1.29 (0.92–1.79, <i>P</i> = 0.126) | 1.35 (0.96–1.90, <i>P</i> = 0.089) |
| Indication | Benign | 430 (21.8) | 64 (19.7) | – | – |
| | Malignant | 1542 (78.2) | 261 (80.3) | 1.14 (0.85–1.54, <i>P</i> = 0.391) | 0.91 (0.64–1.29, <i>P</i> = 0.588) |
| Resection location | Left colon | 750 (38.0) | 112 (34.5) | – | – |
| | Right colon | 1222 (62.0) | 213 (65.5) | 1.17 (0.91–1.50, <i>P</i> = 0.218) | – |

Odds ratio (OR) presented with 95% confidence intervals. % shown by column.

SD, Standard deviation; IQR, Interquartile range; IHD, Ischemic heart disease; CVA, Cerebrovascular accident; N/A, Not applicable.

included within this model are not comprehensive; presence of intraabdominal abscess or fistula, previous surgery and surgeon experience were not collected here [17]. Therefore this analysis should be seen as exploratory only. Whilst, this study supports a laparoscopic first approach where feasible, presentation of this data with help tailor informed consent for patients undergoing attempted laparoscopic colonic surgery using simple, easily comprehensible patient factors. Despite equivalent short-term patient outcomes, laparoscopic conversion is not without consequence to patients and health systems. Health economic data from the United States suggests a prolonged length of stay and significant cost implication to laparoscopic conversion (adjusted mean

cost: \$20 165) *vs* planned open (\$18 797) or laparoscopic completed surgery (\$16 206) [18]. Better understanding of why and when colorectal surgeons choose to convert remains an important focus for future research.

We have tried to mitigate against some of the limitations of observational studies in our study methods. In this case, firstly the inherent selection bias for laparoscopic and open surgery may have varied between centres and surgeons, subjecting patients to different outcomes masked by a pooled analysis. This bias is lessened by collating an international dataset that was adjusted using mixed-effects modelling for case-mix, was pre-planned and allows local units to

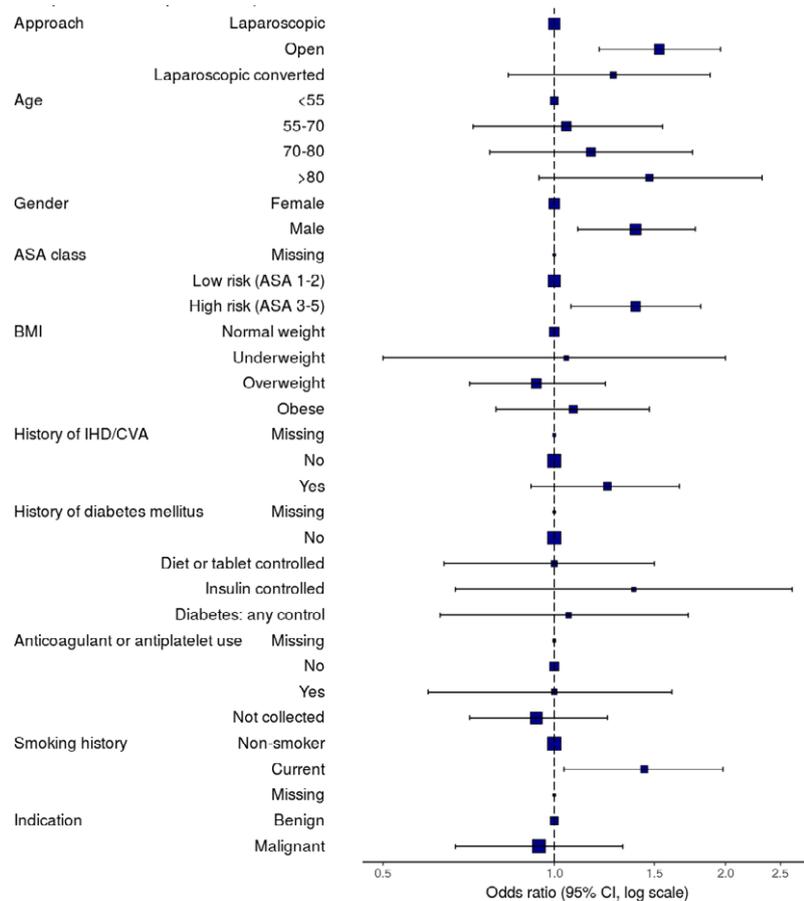


Figure 3 Forest plot demonstrating multilevel model for factors associated with major complications in elective laparoscopic colonic surgery.

benchmark their own performance against. The chance of selection and reporting biases was further reduced by the inclusion of all eligible patients at each centre. Other studies have reported contemporary practice in laparoscopic colonic surgery, including larger patient groups than included here. However, these include data from a single country and are retrospective analyses of registries [16,19]. Prospective data collection, pre-specified analysis plans, and an international cohort from 48 countries increases external validity of our study findings. There was a 2-year interval in data collection between right-sided (2015) and left-sided (2017) resections. Increasing surgeon experience over these 2 years may have led to reduced conversions and improved postoperative outcomes within the left-sided resection group. However, the site of resection was not identified as a significant predictor of conversion, indicating that this short interval did not have a significant impact on this study.

Although we did not analyse by unit or country (as pre-planned in the study protocol), identifying and

reaching units that have low laparoscopy rates to safely increase patients’ access to technology should be a priority. The introduction of laparoscopic colonic surgery over the past 25 years is a model for dissemination of new surgical techniques and makes this an example of an IDEAL phase 4 study [20].

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Conflicts of interest

None to declare.

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Authorship list (PubMed Citable)

Writing group

James Glasbey, Anne van der Pool, Alexandra Rawlings, Luis Sánchez-Guillén, Sara Kuiper, Ionut Negoii, Nicolas Buchs, Dmitri Nepogodiev, Thomas Pinkney, Aneel Bhangu (Chair)

ESCP cohort studies and audits committee

Alaa El-Hussuna (2017 Audit Lead), Nick J. Battersby, Aneel Bhangu, Nicolas C. Buchs, Christianne Buskens, Sanjay Chaudri, Matteo Frasson, Gaetano Gallo, James Glasbey, Ana María Minaya-Bravo, Dion Morton, Ionut Negoii, Dmitri Nepogodiev, Francesco Pata, Tomas Poskus, Luis Sánchez-Guillén, Baljit Singh, Oded Zmora, Thomas Pinkney (Chair)

Statistical analysis and data management

James Glasbey, Dmitri Nepogodiev, Rita Perry, Laura Magill, Aneel Bhangu (Guarantor)

ESCP research committee

Dion Morton (Chair), Donato Altomare, Willem Bemelman, Steven Brown, Christianne Buskens, Quentin Denost, Charles Knowles, Søren Laurberg,

Jérémie H. Lefevre, Gabriela Möeslein, Tom Pinkney, Carolynne Vaizey, Oded Zmora

ESCP 2017 audit collaborators

Albania: S. Bilali, V. Bilali (University Hospital Center Mother Teresa).

Argentina: M. Salomon, M. Cillo, D. Estefania, J. Patron Uriburu, H. Ruiz (Buenos Aires British Hospital); P. Farina, F. Carballo, S. Guckenheimer (Hospital Pirovano).

Australia: D. Proud, R. Brouwer, A. Bui, B. Nguyen, P. Smart (Austin Hospital); A. Warwick, J. E. Theodore (Redcliffe Hospital).

Austria: F. Herbst, T. Birsan, B. Dauser, S. Ghaffari, N. Hartig (Barmherzige Brüder, Wien); A. Stift, S. Argeny, L. Unger (Medical University of Vienna); R. Strouhal, A. Heuberger (Oberndorf b. Salzburg).

Belarus: A. Varabei, N. Lahodzich, A. Makhmudov, L. Selniahina (Minsk Regional Clinical Hospital).

Belgium: T. Feryn, T. Leupe, L. Maes, E. Reynvoet, K. Van Langenhove (AZ Sint-Jan Brugge); M. Nachtergaele (AZ St Jozef); B. Monami, D. Francart, C. Jehaes, S. Markiewicz, J. Weerts (Clinique St Joseph, Liege); K. Van Belle, B. Bomans, V. Cavenaile, Y. Nijs, M. Vertruyen (Europe Hospitals Brussels); P. Pletinckx, D. Claeys, B. Defoort, F. Muysoms, S. Van Cleven (Maria Middelaes Gent); C. Lange, K. Vindevoghel (OLV van Lourdes Hospital Waregem); A. Wolthuis, A. D'Hoore (University Hospital Leuven).

Bosnia and Herzegovina: M. Todorovic, S. Dabic, B. Kenjic, S. Lovric, J. Vidovic (JZU Hospital Sveti Vračevi); S. Delibegovic, Z. Mehmedovic (University Clinic Center Tuzla).

Brazil: A. Christiano, B. Lombardi, M. Marchiori Jr, V. Terciotti Jr (Hospital Centro Médico de Campinas).

Bulgaria: D. Dardanov, P. Petkov, L. Simonova, A. Yonkov, E. Zhivkov (Alexandrovska Hospital - First Surgery); S. Maslyankov, V. Pavlov, M. Sokolov, G. Todorov (Alexandrovska Hospital, Second Surgery Clinic); V. Stoyanov, I. Batashki, N. Iarumov, I. Lozev, B. Moshev (Medical Institute - Ministry of Interior); M. Slavchev, B. Atanasov, N. Belev, P. Krstev, R. Penkov (University Hospital - Eurohospital).

Croatia: G. Šantak, J. Čosić, A. Previšić, L. Vukušić, G. Zukanović (County Hospital Požega); M. Zelić, D. Kršul, V. Lekić Vitlov, D. Mendrila (University Hospital Rijeka).

Czech Republic: J. Orhalmi, T. Dusek, O. Maly, J. Paral, O. Sotona (Charles University Hospital). M. Skrovina, V. Bencurik, M. Machackova (Complex Oncology Centre Novy Jicin, Surgical Department); Z. Kala, M. Farkašová, T. Grolich, V. Procházka (Surgical

Department, University Hospital Brno); J. Hoch, P. Kocian, L. Martinek (University Hospital Motol, Prague); F. Antos, V. Pruchova (University Hospital Prague Bulovka).

Denmark: A. El-Hussuna, A. Ceccotti, T. Madsbøll, D. Straarup, A. Uth Ovesen (Aalborg University Hospital); P. Christensen, P. Bondeven, P. Edling, H. Elfeki, V. Alexandrovich Gameza, S. Michelsen Bach, I. Zheltiakova (Aarhus University Hospital/Randers Regional Hospital); PM. Krarup, A. Krogh, H-C. Rolff (Bispebjerg); J. Lykke, A. F. Juvik, H. H. K. Lóven, M. Marckmann, J. T. F. Osterkamp (Herlev Hospital); A. H. Madsen, J. Worsøe (Hospital Unit West); A. Ugianskis (North Denmark Regional Hospital); M. D. Kjær, B. Youn Cho Lee (Odense University Hospital); A. Khalid, M. H. Kristensen (Regional Hospital Viborg).

Egypt: M. El Sorogy, A. Elgeidie, M. Elhemaly, A. El Nakeeb, M. Elrefai (Gastrointestinal Surgery Center, Mansoura University); M. Shalaby, S. Emile, W. Omar, A. Sakr, W. Thabet (Mansoura University Hospital); S. Awny, I. Metwally, B. Refky, N. Shams, M. Zuhdy (Oncology Center Mansoura University).

Finland: A. Lepistö, I. Keränen, A. Kivelä, T. Lehtonen, P. Siironen (Helsinki University Hospital); T. Rautio, M. Ahonen-Siirtola, K. Klintrup, K. Paarnio, H. Takala (Oulu University Hospital); M. Hyöty, E. Haukijärvi, S-M. Kotaluoto, K. Lehto, T. Tomminen (Tampere University Hospital); H. Huhtinen, A. Carpelan, J. Karvonen, A. Rantala, P. Varpe (Turku University Hospital).

France: E. Cotte, Y. Francois, O. Glehen, G. Passot (Centre Hospitalier Lyon Sud); A. d'Alessandro, E. Chouillard, J. C. Etienne, E. Ghilles, B. Vinson-Bonnet (Centre Hospitalier Poissy Saint Germain en Laye); A. Germain, A. Ayav, L. Bresler (CHU Nancy-Brabois); R. Chevalier, Q. Denost, R. Didailler, E. Rullier (Hopital Haut Leveque); E. Turet, N. Chafai, J. H. Lefevre, Y. Parc (Hôpital Saint-Antoine); I. Sielezneff, D. Mege (Timone Hospital); Z. Lakkis (University Hospital of Besancon); M. Barussaud (University Hospital of Poitiers).

Germany: C. Krones, B. Bock, R. Webler (Marienhospital Aachen); J. Baral, T. Lang, S. Münch, F. Püllig, M. Schön (Städtisches Klinikum Karlsruhe); S. Hinz, T. Becker, T. Möller, F. Richter, C. Schafmayer (University Hospital Schleswig-Holstein, Kiel); J. Hardt, P. Kienle (University Medical Center Mannheim); F. Crescenti, M. Ahmad, Y. Soleiman (Verden KRH).

Greece: I. Papaconstantinou, A. Gklavas, K. Nastos, T. Theodosopoulos, A. Vezakis (Areteion Hospital); K. Stamou, A. Saridaki (Athens Bioclinic); E. Xynos, S. Paraskakis, N. Zervakis (Creta-InterClinic Hospital); G. Skroubis, T. Amanatidis, S. Germanos, I. Maroulis, G.

Papadopoulos (General University Hospital of Patras); N. Dimitriou, A. Alexandrou, E. Felekouras, J. Griniatsos, I. Karavokyros (Laiko Hospital); A. Papadopoulos, C. Chouliaras, P. Ioannidis, D. Katsounis, E. Kefalou (Nikaia General Hospital); I. E. Katsoulis, D. Balalis, D. P. Korkolis, D. Manatakis (St. Savvas Cancer Hospital); G. Tzouvaras, I. Baloyiannis, I. Mamaloudis (University Hospital of Larissa).

Hungary: G. Lázár, S. Ábraham, A. Paszt, Z. Simonka, I. Tóth (Department of Surgery, University of Szeged); A. Zaránd, Z. Baranyai, G. Ferreira, L. Harsányi, P. Ónody (Semmelweis University, 1st Clinic of Surgery); B. Banky, Á. Burány, M. Lakatos, J. Marton, A. Solymosi (St. Borbala Hospital); I. Besznyák, A. Burics, G. Papp, G. Saftics, I. Svastics (Uzsoki Hospital);

Iceland: E. Valsdottir, J. Atladottir, T. Jonsson, P. Moller, H. Sigurdsson (University Hospital of Iceland).

India: S. K. Gupta, S. Gupta, N. Kaul, S. Mohan, G. Sharma (Government Medical College, Jammu, Jammu and Kashmir, India); R. Wani, N. Chowdri, M. Khan, A. Mehraj, F. Q. Parray (Sher-i-Kashmir Institute of Medical Sciences).

Ireland: A. Coveney, J. Burke, J. Deasy, S. El-Masry, D. McNamara (Beaumont Hospital); M. F. Khan, R. Cahill, E. Faul, J. Mulsow, C. Shields (Mater Misericordiae University Hospital); D. Winter, R. Kennelly, A. Hanly, M. Ismaiel, S. Martin, D. Ahern, M. Kelly, G. Bass, R. O'Connell (St. Vincent's University Hospital, Dublin); T. Connelly, G. Ahmad, W. Bukhari, F. Cooke (University Hospital Waterford).

Israel: O. Zmora, R. Gold Deutch, N. Haim, R. Lavy, A. Moscovici (Assaf Harofe Medical Center); N. Shussman, R. Gefen, G. Marom, A. Pikarsky, D. Weiss (Hadassah Hebrew University Medical Center); S. Avital, N. Hermann, B. Raguán, M. Slavin, I. White (Meir Medical Center); N. Wasserberg, H. Arieli, N. Gurevich (RMC, Beilinson Campus); M. R. Freund, S. Dorot, Y. Edden, G. Halfteck, P. Reissman (Shaare Zedek Medical Center); Y. Edden, R. Pery (Sheba Medical Center); H. Tulchinsky, A. Weizman (Sourasky Medical Center).

Italy: F. Agresta, R. Curinga, E. Finotti, G. Savino, L. A. Verza (Adria Hospital); C. R. Asteria, L. Boccia, A. Pascariello (ASST - Mantua); N. Tamini, A. Bugatti, L. Gianotti, M. Totis (Asst-Monza, Ospedale San Gerardo); L. Vincenti, V. Andriola, I. Giannini, E. Travaglio (Azienda Ospedaliero Universitaria Consorziale Policlinico di Bari); R. Balestri, P. Bucciatti, N. Roffi, E. Rossi, L. Urbani (Azienda Ospedaliero Universitaria Pisana); A. Mellano, A. Cinquegrana (Candiolo Cancer Institute IRCCS); A. Lauretta, C. Belluco (Chirurgia Oncologica Generale, IRCCS Centro di Riferimento Oncologico, Aviano); M. Mistrangelo, M. E. Allaix, S. Arolfo, M. Morino, V. Testa (Citta della Salute e della

Scienza di Torino); P. Delrio, U. Pace, D. Rega, D. Scala (Division of Colorectal Surgery, Department of Abdominal Surgery, Istituto Nazionale Tumori "Fondazione G.Pascale", IRCCS Naples); G. Gallo, G. Clerico, S. Cornaglia, A. Realis Luc, M. Trompetto (Department of Colorectal Surgery, S. Rita Clinic); G. Ugolini, N. Antonacci, S. Fabbri, I. Montroni, D. Zattoni (Faenza Hospital); C. D'Urbano, A. Cornelli, M. Viti (G. Salvini); M. Inama, M. Bacchion, A. Casaril, H. Impellizzeri, G. Moretto (Hospital Dott. Pederzoli); A. Spinelli, M. Carvello, G. David, F. Di Candido, M. Sacchi (Humanitas Research Hospital); A. Frontali, V. Ceriani, M. Molteni (IRCCS MultiMedica); R. Rosati, F. Aleotti, U. Elmore, M. Lemma, A. Vignali (IRCCS San Raffaele, Department of Gastrointestinal Surgery); S. Scabini, G. Casoni Pattacini, A. Luzzi, E. Romairone (Policlinico San Martino, Genoa); F. Marino, D. Lorusso, F. Pezzolla (Dept. of General Surgery, IRCCS "Saverio de Bellis", Castellana Grotte (Ba)); F. Colombo, C. Baldi, D. Foschi, G. Sampietro, L. Sorrentino (L. Sacco University Hospital); S. Di Saverio, A. Birindelli, E. Segalini, D. Spacca (Maggiore Hospital); G. M. Romano, A. Belli, F. Bianco, S. De franciscis, A. Falato (Surgical Oncology Istituto Nazionale Tumori G.Pascale Naples); A. Muratore, P. Marsanic (Ospedale Agnelli Pinerolo); S. Grimaldi, N. Castaldo, M. G. Ciolli, P. Picarella, R. Porfidia (Ospedale Convenzionato Villa dei Fiori Acerra); S. Di Saverio, A. Birindelli, G. Tugnoli (Ospedale Maggiore); A. Bondurri, D. Cavallo, A. Maffioli, A. Pertusati (Ospedale Sacco Italy); F. Pulighe, F. Balestra, C. De Nisco, M. Podda (Ospedale San Francesco); E. Opocher, M. Longhi, N. M. Mariani, N. Maroni, A. Pisani Ceretti (Ospedale San Paolo); R. Galleano, P. Aonzo, G. Curletti, L. Reggiani (Ospedale Santa Corona); M. Marconi, L. Del Prete, M. Oldani, R. Pappalardo, S. Zaccone I (Ospedale Santa Maria delle Stelle); M. Scatizzi, M. Baraghini, S. Cantafio, F. Feroci, I. Giani (Ospedale Santo Stefano, Prato); R. Tutino, G. Cocorullo, G. Gulotta, L. Licari, G. Salamone (Policlinico 'P. Giaccone'); P. Sileri, F. Saraceno (Policlinico Tor Vergata); F. La Torre, P. Chirletti, D. Coletta, G. De Toma, A. Mingoli (Policlinico Umberto I 'Sapienza University'); M. Papandrea, E. De Luca, R. Sacco, G. Sammarco, G. Vescio (Policlinico Universitario di Catanzaro); V. Tonini, S. Bianchini, M. Cervellera, S. Vaccari (Policlinico universitario Sant'Orsola-Malpighi, Università degli Studi di Bologna); N. Cracco, G. Barugola, E. Bertocchi, R. Rossini, G. Ruffo (Sacro Cuore Don Calabria Hospital); A. Sartori, N. Clemente, M. De Luca, A. De Luca, G. Scaffidi (San Valentino Hospital); L. Lorenzon, G. Balducci, T. Bocchetti, M. Ferri, P. Mercantini (Sant'Andrea Hospital); F. Pata, S. Bauce, A. Benevento, C. Bottini, P. R. Crapa

(Sant' Antonio Abate Hospital, Gallarate); M. Rubbini, G. Anania, P. Carcoforo, G. Cavallesco, C. Feo (University Hospital of Ferrara).

Japan: T. Yamamoto (Yokkaichi Hazu Medical Centre).

Latvia: A. Sivins, G. Ancans, S. Gerkis, R. Lunis, A. Pcolkins (Latvia Oncology Center).

Lithuania: D. Venskutonis, S. Bradulskis, E. Dainius, A. Subocius, J. Vencius (Department of General Surgery, LSMU, Kaunas Clinical Hospital); P. Zeromskas, V. Eismontas, V. Nutautiene, D. Simcikis, A. Tamosiunas (Klaipeda University Hospital); S. Svagzdys, T. Latkauskas, P. Lizdenis, Z. Saladzinskas, A. Tamelis (Lithuanian University of Health Sciences Hospital Kauno Klinikos); A. Dulskas, J. Kuliavas, N. E. Samalavicius (National Cancer Institute, Lithuania); T. Poskus, V. Jotautas, S. Mikalauskas, E. Poskus, K. Strupas (Vilnius University).

Malaysia: A. D. Zakaria, N. N. Lah, M. Wong, W. Z. Zain, Z. Zakaria (Department of Surgery, School of Medical Sciences, Universiti Sains Malaysia / Hospital Universiti Sains Malaysia); L. Mazlan, Z. A. Mohd Azman, I. Sagap (UKM Medical Centre).

Malta: J. Psaila, P. Andrejevic, C. Cini, S. Ellul, K. Pace (Mater Dei Hospital). Morocco: M. Ahallat, M. Hamid, A. Hrra, M. A. Majbar, M. Raiss (Ibn Sina University Hospital).

Netherlands: E. Westerduin, W. Bemelman, C. Buskens, P. Tanis (Academic Medical Centre); P.C. van der Sluis, P.H. Davids, A. Pronk, A.H.W. Schiphorst, N. Smakman (Diakonessenhuis); D. Zimmerman, T. Koeter, J. Stijns, Y-T. van Loon (Elisabeth TweeSteden Hospital); M. Vermaas, E. de Graaf, P. Doornebosch, P. van Hagen, O. van Ruler (Ijsselland Ziekenhuis); B. Toorenvliet, J. Nonner, I. van den Berg, L. van Steensel, W. Vles (Ikazia); J. Melenhorst, R. Orsini, R. Visschers (Maastricht University Medical Centre); C. Hoff (Medical Center Leeuwarden); R. Blom, H. Marsman (Onze Lieve Vrouwe Gasthuis); I. Mulder, H. Cense, S. de Castro, A. Demirkiran, M. Hunfeld (Rode Kruis Ziekenhuis Beverwijk); A. van Geloven, J. de Groof, E. Hendriks, M. Leeuwenburg, N. van Oorschot (Tergooi); F. Wit, C. Rupert, P. Veldman (Tjongerschans ziekenhuis); M. Keijzers, J. Konsten (VieCuri Medisch Centrum voor Noord Limburg); F. Den Boer, M. Corver (Zaans Medical Center); E. G. Boerma, L. Koolen, M. Martens, K. Van Wijck (Zuyderland Medical Center).

Norway: D. Ignjatovic, R. Breuer, B. Gurpreet, T. Oresland, T. Tetens Moe (Akershus University Hospital); A. Nesbakken, I. Flaaten Backe, T-A. Wik (Oslo University Hospital); K. Radiya, T. Dehli, P. Gjessing, S. Norderval, K. Woll (University Hospital of North Norway).

Pakistan: M. Anwer, M. S. Qureshi (JPMC WARD 2); A. U. Qureshi, M. Billah, M. Y. Jawad, A. Raza, N. Urooj (King Edward Medical University/Mayo Hospital, Lahore).

People's Republic of China: X. Wang, L. Li (West China Hospital in Sichuan University).

Poland: D. Jajtner, B. Gasinski, W. Kabiesz (Beskidian Oncology Center); P. Walega, M. Romaniszyn (Third Department of General Surgery, Jagiellonian University Medical College); M. Zawadzki, R. Czarnecki, Z. Obuszko, M. Rzaca, M. Sitarska (Wojewódzki Szpital Specjalistyczny).

Portugal: P. Silva, A. Duarte, D. Gonçalves, M. Morais (Centro Hospitalar de S. João); N. Rama, J. Nobre, I. Sales (Centro Hospitalar Leiria, EPE); J. Costa Pereira, S. Costa, C. Costa Pereira, C. Insua, I. Romero (Centro Hospitalar Tâmega e Sousa); N. Figueiredo, J. Cunha, H. Domingos, P. Vieira (Champalimaud Foundation); M. Cunha, M. Americano, E. Amorim, J. Rachadell (Cirurgia 2 - CHA - Unidade Portimão); J. M. Carvas, I. Armas, P. Fernandes, C. Pires, R. Reis (Hospital de Bragança); R. Martins, M. Dos Santos, P. Henriques (Hospital de Faro, Centro Hospitalar do Algarve); O. Oliveira, M. Duarte, L. Ferreira, J. Miranda, N. Vilela (Hospital Distrital de Santarém, E.P.E.); J. Corte Real, S. Carlos, M. Frois Borges, P. Moniz Pereira, J. Simões (Hospital Garcia de Orta); P. Silva-vaz, V. Bettencourt, A. Gouveia, H. Perez, R. Rainho (Unidade Local de Saúde de Castelo Branco).

Romania: V. Bintintan, C. Ciuce, G. Dindelegan, R. Scurtu, R. Seicean (Clinica Chirurgie I); D. Cristian, T. Burcos, F. Grama, D. M. Mandi, G. Richiteanu (Coltea Clinical Hospital); A. Miron, V. Calu, O. Enciu, M. Nadragea, R. Parvuletu (Elias Emergency Hospital); S. S. Mogoanta, A. Crafcu, S. Paitici (Emergency County Hospital of Craiova); I. Negoii, M. Beuran, C. Ciubotaru, A. Prodan, M. Vartic (Emergency Hospital of Bucharest); V. Tomulescu, C. Copaescu (Ponderas Academic Hospital).

Russia: A. Yanishev, A. Abelevich, A. Kokobelyan, M. Lebedeva, R. Luzan (FSBEI HE PRMU MOH); A. Pozdnyakov, D. Cherdancev, D. Mahotin, A. Nesytykh, V. Samsonyuk (Krasnoyarsk Regional Clinical Hospital); I. Pravosudov, D. Ivlev, A. Karachun, K. Lebedev, D. Samsonov (N.N. Petrov National Medical Research Center of Oncology); R. Aiupov, D. Feoktistov, M. Garipov, N. Suleymanov, N. Tarasov (Republican Oncological Centre, Ufa); A. Rasulov, H. Dzhumabaev, Z. Mamedli (Russian Cancer Research Center); A. Bedzhanyan (Russian Research Center of Surgery named after B.V.Petrovsky); D. Popov, A. Sednev, A. Klimenko, A. Semenov, S. Vasilyev (Saint-Petersburg City

Hospital 9); A. Khazov, M. Khanevich, G. Khrykov (Saint-Petersburg Clinical Oncological Health Center); S. Katorkin, P. Andreev, A. Chernov, O. Davidova, A. Zhuravlev (Samara State Medical University); S. Achkasov, D. Shakhmatov, Y. Shelygin, O. Sushkov, A. Vardanyan (State Scientific Centre of Coloproctology); A. Ilkanich, N. Barbashinov, V. Darwin, S. Onishchenko, Y. Voronin (Surgut District Hospital).

Serbia: Z. Krivokapić, G. Barišić, I. Dimitrijević, V. Marković, A. Sekulić (Clinic for Digestive Surgery-First Surgical Clinic, Clinical Center of Serbia, University of Belgrade, Medical Faculty); G. Stanojevic, B. Brankovic, M. Nestorovic, V. Pecic, D. Petrovic (Clinic for General Surgery, Clinical Center Nis); I. Kostic, A. Aleksic, D. Dabic, B. Maric, V. Perunicic (General Hospital Cacak); Z. Radovanovic, M. Djuric, D. Lukic, D. Radovanovic (Oncology Institute of Vojvodina); V. Cuk, V. Cuk, J. Juloski, M. Kenic, I. Krdzic (Surgical Clinic KBC Zvezdara).

Singapore: J. C. Ngu, Y. Y. Ng, N. Teo (Changi General Hospital).

Slovak Republic: J. Korcek, A. Lazorisak, (Faculty Hospital Nitra).

Slovenia: M. Rems, Š. Ramovš Trampuš (General Hospital Jesenice); A. Tomazic, J. Grosek, J. Kosir, G. Norcic (University Medical Centre Ljubljana).

Spain: V. Vigorita, N. Caceres, E. Casal, A. Ruano, I. Trostchansky (Alvaro Cunqueiro Hospital); T. Golda, A. Galvez Saldaña, E. Kreisler Moreno, J. Lopez Dominguez, M. Vila Tura (Bellvitge University Hospital); F. Labarga, P. Galvez, V. Maderuelo, C. Suero (Complejo Asistencial Universitario de Palencia); J. Bargallo, L. Cayetano, S. Lamas, M. C. Silva (Consorci Sanitari de Terrassa - Hospital de Terrassa); J. C. Bernal-Sprekelsen, R. Gómez, S. Jareño, A. Ríos, D. Vercher (Consorcio Hospital General Universitario); J-M. García-González, J. Cervera-Aldama, J. Ramos-Prada, M. Santamaría-Olabarrieta (Cruces University Hospital); N. Borda, J. M. Enríquez-Navascués, Y. Saralegui (Donostia University Hospital); A. Calero-Lillo, S. Aznar-Puig, M. A. López-Lara, S. Muñoz-Collado, J. Valverde-Sintas (Fundacio Hospital Esperit Sant); P. Menendez, C. Leon (Gutierrez Ortega Hospital); N. Truan, R. Baldonado, D. Fernández-Martínez, J. Otero, L. Solar-García (Hospital Universitario Central de Asturias); V. Turrado-Rodríguez, F. de Lacy Oliver, A. M. Lacy Fortuny, B. Martín Perez, A. M. Otero Piñeiro (Hospital Clinic Barcelona); J. Paredes, F. Fernandez, M. J. Ladra, A. Paulos, D. Prieto (Hospital Clinico Universitario de Santiago de Compostela); J. P. Beltrán de Heredia, F. Blanco Antona, B. de Andrés Asenjo, C. Ferreras García, A. Romero de Diego (Hospital Clínico Universitario de Valladolid); E. Cordoba Diaz de

Laspra, E. Echazarreta Gallego, M. Elia Guedea (Hospital Clinico Universitario de Zaragoza); D. Escola, S. Martinez (Hospital Comarcal Alt Penedes); V. Primo Romaguera, R. Parreño, L. Pastor, E. Rosell (Hospital de Dénia); R. Lozoya Trujillo, R. Alós Company, M. D. Ruiz Carmona, A. Solana Bueno (Hospital de Sagunto); S. Salvans Ruiz, S. Alonso Gonçalves, M. Jiménez-Toscano, M. Pascual Damieta, M. Pera Roman (Hospital Del Mar); E. M. Pellicer-Franco, J. A. Garcia-Marin, M. Mengual-Ballester, V. Soria-Aledo, G. Valero-Navarro (Hospital Morales Meseguer); M. Vicente-Ruiz, C. Garcia-Zamora, A. Gonzalez-Gil, M. J. Montoya-Tabares, M. Paredes-Quiles (Hospital Rafael Mendez); J. Die Trill, P. Abadia, I. Moreno, J. D. Pina, D. Ramos Rubio (Hospital Ramon y Cajal); J. Escartin, J. L. Blas, J. Fernando, R. Ferrer, J. Garcia Egea (Hospital Royo Villanova); I. Pros, W. Martinez, J. Rius, M. Sociás (Hospital Sant Joan de Deu de Martorell); D. Sabia, J. Castellvi Valls, V. Gonzalez Santin, S. Mompert Garcia, L. Viso Pons (Hospital Sant Joan Despí Moises Broggi); D. Julià, A. Codina-Cazador, R. Farrés, N. Gómez, P. Planellas (Hospital Universitari de Girona Doctor Josep Trueta); M. Cuadrado, I. Camps (Hospital Universitari Germans Trias I Pujol); M. Rufas, J. Escoll, A. Ferminán, P. Muriel, E. Sierra (Hospital Universitario Arnau de Vilanova de Lerida); C. Alvarez-Laso, P. Lora, H. Padin (Hospital Universitario de Cabueñes); J. Garcia-Septiem, C. Bustamante, V. Jimenez, J. Jimenez-Miramón, J. L. Ramos (Hospital Universitario de Getafe); A. B. Gallardo, P. Benito, L. Colao, P. Galindo, C. Garcia (Hospital Universitario de Torrejón de Ardoz); A. Forero-Torres, A. Alonso Poza, B. Dieguez Fernandez, C. Gilsanz Martin, M. Hernandez Garcia (Hospital Universitario del Sureste); J. A. Rojo López, J. M. Gil López, M. González Zunzáren, J. Martínez Alegre, L. P. Zorrilla Matilla (Hospital Universitario Infanta Sofia); A. Navarro-Sánchez, F. J. Alcalá Serrano, J. López-Fernández, D. Montesdeoca Cabrera (Hospital Universitario Insular de Gran Canaria); M. Alvarez-Gallego, J. Guevara, I. Pascual Miguelañez, I. Rubio-Perez (Hospital Universitario La Paz); M. Gomez Ruiz, J. Alonso Martín, C. Cagigas Fernández, J. Castillo Diego (Hospital Universitario Marques de Valdecilla); J. A. Pando, C. Maristany, A. Muñoz-Duyos, A. Rada-Palomino, H. Vargas-Pierola (Hospital Universitario Mutua Terrassa); E. Peña Ros, J. A. Benavides Buleje, J. M. Muñoz Camarena, P. A. Parra Baños, M. Ramirez Faraco (Hospital Universitario Reina Sofía); J. J. Arenal, M. A. Citores, J. L. Marcos, J. Sánchez, C. Tinoco (Hospital Universitario Río Hortega); L. J. García Flórez, R. D. Arias Pacheco, G. Mínguez Ruiz, N. Gutiérrez Corral, A. Rodríguez Infante (Hospital Universitario San Agustín); M. J.

Carrillo López, M. M. Carrasco Prats, A. Lage Laredo, Á. Martínez Manzano, P. Rodríguez García (Hospital Universitario Santa Lucia); J. J. Segura-Sampedro, N. Alonso-Hernández, M. Fernandez Isart, M. Gamundi Cuesta, A. Ochogavía Seguí (Hospital Universitario Son Espases); N. Ibañez, J. Abrisqueta, J. Lujan (Hospital Universitario Virgen de la Arrixaca); R. Gómez Pérez, E. Corrales Valero, C. Monje Salazar, E. Sanchiz Cardenas, R. Soler Humanes (Hospital Universitario Virgen de la Victoria); R. M. Jimenez-Rodríguez, F. De la Portilla, J. M. Diaz Pavon, A. M. Garcia Cabrera, M. L. Reyes Diaz (Hospital Universitario Virgen del Rocío); E. Espin, F. Marinello, M. Martí, J. L. Sanchez, F. Vallribera (Hospital Valle de Hebron); F. J. Orts Mico, M. Ortin Navarro, M. Perez Climent, C. Serra Diaz (Hospital Virgen de los Lirios); M. Millan, A. Caro, J. Escuder, B. Espina, F. Feliu (Joan XXIII University Hospital); A. Climent Aira, A. Estévez Diz, M. T. Moreno Asencio, A. Varela Mato, R. Vázquez Bouzán (POVISA Hospital); A. M. Minaya-Bravo, M.M. Diez-Alonso, R. Villeta-Plaza (Principe de Asturias Hospital); H. Guadalajara, D. Alías, D. García Olmo, C. Pastor, I. Valverde (Quironsalud Publicos); A. Sanchez Romero, A. Gardea, M. Gil Santos, T. Nimmersgern, P. Serrano Paz (Unidad de Coloproctología, Hospital Vinalopó-Torre Vieja); M. Romero-Simó, T. Blasco-Segura, I. Caravaca-García, D. Costa-Navarro, A. Zarco-Pleguezuelos (University General Hospital of Alicante); L. Sánchez-Guillén, B. Flor-Lorente, M. Frasson, Á. García-Granero, E. García-Granero (University Hospital La Fe Valencia); B. Arencibia, J. Alonso, G. Febles, E. M. Nogués, C. Roque (University Hospital of Gran Canaria Dr. Negrín).

Sweden: J. Segelman, J. Nygren (Ersta Hospital); G. Nestler (Falun lasarett); M. Abraham-Nordling, M. Egenvall (Karolinska University Hospital); P. Myrelid, B. Jung, P. Loftås (Linköping University Hospital); M-L. Lydrup, N. Azahr, P. Buchwald, P. Mangell, I. Syk (Skane University Hospital); M. Nikberg, J. Carlander, A. Chabok, K. Smedh, C. Tiselius (Västmanlands Hospital Västerås); S. Haapaniemi, A. Benckert (Vrinnevi Hospital Norrköping).

Switzerland: M. Adamina, C. Freil-Lanter, C. Gिंगert, P. Müller, J. Schäfli (Kantonsspital Winterthur); L. Regusci, M. Brenna, F. Fasolini (Regional Hospital Mendrisio); H. Misteli, P. Kirchoff, D. Oertli (University Hospital Basel, Switzerland); D. Hahnloser, D. Clerc, M. Hübner (University Hospital of Lausanne, CHUV); F. Ris, N. C. Buchs, M. Chevally, P. Morel, B. Schiltz (University Hospitals Geneva).

Taiwan: J. Y. Wang, W-C. Su, C-W. Huang, C-J. Ma, H-L. Tsai (Kaohsiung Medical University Hospital).

Turkey: D. Bugra (American Hospital); F. Agalar, H. Baloglu, I. Basoglu (Anadolu Medical Center [in aff

with Johns Hopkins Med]); N. Okkabaz, E. Binboga, A. Biricik, A. Celik, E. Yavuz (Bagcilar Training and Research Hospital); A. E. Canda, C. Agalar, M. Fuzun, S. Sokmen, C. Terzi (Dokuz Eylul University); A. Isik (Erzincan University, Mengucek Gazi Training and Research Hospital); B. Karip, A. C. Bilgili (Fatih Sultan Mehmet Training and Research Hospital); S. Leventoglu, B. Aytac, E. Küçükdiler, A. Yıldız, O. Yuksel (Gazi University Medical School); H. Sinan, O. Hancerliogullari, S. Kaymak, O. Kozak, M. T. Ozer (Gulhane Training and Research Hospital); I. S. Sarici, O. Akca, M. U. Kalayci, Y. Kara (Kanuni Sultan Suleyman Training and Research Hospital); D. Bugra, O. Agcaoglu, E. Balik, O. Bayram (Koc University School of Medicine); G. S. Özbacı, B. B. Özkan, U. Karabacak (On Dokuz Mayıs University Faculty of Medicine); U. Sungurtekin, U. Ozgen (Pamukkale University School of Medicine); S. Demirbas (TOBB-ETU University Hospital); E. Öztürk, O. Isik, T. Yilmazlar (Uludag University School of Medicine); E. Colak, S. Karagul, V. Kinas (University of Health Sciences, Samsun Training and Research Hospital).

UK: N. Fearnhead, I. Lord, P. Stewart (Addenbrooke's [Cambridge University] Hospital); M. Zammit (Basildon Hospital); S. Arnold, N. J. Battersby, J. Broadhurst, S. Moran, F. Seretis (Basingstoke and North Hampshire Hospital); J. Shabbir, C. Jones, J. Kynaston (Bristol Royal Infirmary); D. Vimalachandran, E. Blower, C. McFaul, D. McWhirter, J. Pilkington (Countess of Chester Hospital); T. Wilson, M. Chowdhary (Doncaster Royal Infirmary); B. Stubbs, M. Abdalkoddus, C. Lai, N. Thavanesan, C. Yao (Dorset County Hospital); T. Agarwal, S. Dindyal, R. M. C. Hill, S. Reade, A. Slesser (Ealing Hospital); H. Pater-son, A. Balfour, M. Boland, A. Geraghty, J. O'Kelly (Edinburgh Western General Hospital); P. Patel, S. Tezas (Furness General Hospital); S. Yahia, V. Jadhav, K. Marimuthu, A. Narayanan, B. Piramanayagam (George Eliot Hospital); N. Bradley, F. Buchanan, K. Paul, J. Singh, K. Thomson (Glasgow Royal Infirmary); S. Korsgen, M. Bedford, K. Lee, K. Leong (Good Hope Hospital); D. McArthur, A. Bhangu, S. Malik, I. Mohamed (Heartlands Hospital); P. Cunha, A. Pilavas (Homerton University Hospital NHS Trust); A. Reddy, S. Ahmed, A. Ahmed, J. Voll (James Cook University Hospital); V. Velchuru, R. Lal, B. Mirshekar-Syahkal (James Paget Hospital); M. Kassai, M. Aleem, S. Keogh-Bootland (Jersey General Hospital); P. Sarmah, S. Brown, R. Keegan, A. Kelkar, P. Sen (Kettering General Hospital); M. Oliveira-Cunha, S. Chaudhri, R. Fares, B. Singh, W. M. Thomas (Leicester General Hospital); M. I. Aslam, K. Boyle, D. Hemingway, A. Miller, M. Norwood (Leicester Royal Infirmary);

S. Gurjar, M. Al-Saedi, L. Anandan, A. Sudlow, N. Zampitis (Luton & Dunstable Hospital); K. Malik, M. Bogdan, C. Smart (Macclesfield District General Hospital); M. R. Iqbal, S. Bailey, D. Lawes, G. Omar, R. Tamhane (Maidstone and Tunbridge Wells NHS Trust); M. Evans, S. Ather, J. Lim, H. Nageswaran, G. Taylor (Morrison Hospital); L. Hunt, J. Nicholls (Musgrove Park Hospital); I. Shaikh, F. Muscara, J. O'Brien, E. Photi, A. Stearns (Norfolk and Norwich University Hospital); D. Meylemans, C. Cunningham, R. Hompes (Oxford University Hospitals); A. Tennakoon, N. Kumarasinghe, M. Rao, I. Upanishad (Pilgrim Hospital); J. Khan, N. Ahmad, Z. Shweejawee, S. Stefan (Queen Alexandra Hospital); N. Smart, I. Daniels, T. Gregoir, L. Longstaff, F. McDermott (Royal Devon & Exeter Hospital); M. Varcada, I. Drami, T. Gala, E. Moggia, K. Ratnatunga (Royal Free Hospital NHS Trust Hampstead); R. Harries, J. Hayes, G. Williams (Royal Gwent Hospital); T. Raymond, C. Bronder, E. Davies, P. Hawkin, O. Ryska (Royal Lancaster Infirmary); K. Ayril, A. Beveridge, A. Bhowmik, M. Gill, R. Simpson (Royal Preston Hospital); A. Schofield, K. McArdle, M. Parmar (Royal Shrewsbury Hospital); M. Williamson, H. Burton, E. Courtney, C. Grant, A. Saracino (Royal United Hospital Bath); K. Newton, J. Epstein (Salford Royal NHS Foundation Trust); G. Branagan, M. Bignell, M. Symanekwicz (Salisbury District Hospital); S. Zaman, R. Mankotia, Z. Siddiqui, A. Torrance (Sandwell General Hospital); D. Artioukh, M. Eggleston, K. Gokul, D. Selwyn (Southport and Ormskirk Hospitals); J. Warusavitarne, P. Chandrasinghe, J. Grainger, C. A. Leo, C. J. Vaizey (St Mark's Hospital); G. Harris, B. Levy, A. Skull (St Richard's Hospital); M. Thaha, S. Ahmed, A. Garg, H. Patel, A. Ramsanahie (The Royal London Hospital, Barts Health NHS Trust); M. Mondragon-Pritchard, K. Cuias Leon, G. Williams (The Royal Wolverhampton NHS Trust); A. Shukla, H. Brewer, J. Fitzgerald, H. Kho (United Lincolnshire Hospitals NHS Trust); J. Torkington, S. Tate, J. Wheat (University Hospital of Wales); S. Smolarek, E. Platt, B. Rossi, J. C. Tham (University Hospitals Plymouth NHS Trust); J. Knight, J. Richardson, A. Tzi vanakis (University Hospital Southampton); M. Gregori, M. A. Ashraf, M. Atif, A. Birindelli, J. Santos (University Hospitals Birmingham NHS FT); N. Saffaf, M. I. Aslam, L. Canning (Warwick Hospital); N. Chandratreya, M. Bowen, B. Graham, Y. Hamad, M. Kaubrys (Weston General Hospital at Weston super Mare); Z. U. Chaudhry, C. Bhan, H. Mukhtar, A. Oshowo, J. Wilson (Whittington Hospital NHS Trust); J. Richardson, N. Gouvas, D. Nicol, S. Pandey, M. Zilvetti (Worcestershire Royal Hospital); A. Sharma, T. Fatayer, S. Mothe, M. Rahman (Wythenshawe Hospital,

UHSM); N. Curtis, A. Allison, R. Dalton, N. Francis, J. Ockrim (Yeovil District Hospital).

Ukraine: G. Psaras, H. Dudarovaska, T. Marharint, E. Mostovoy, S. Voloshin (Mariupol Cancer Center); O. Kolesnik, D. Makhmudov (National Cancer Institute, Ukraine).

United States: Y. Altinel (Cleveland Clinic); A. Iqbal, L. Cunningham, K. Go, S. Tan (University of Florida).

ESCP 2015 audit collaborators

Argentina: M. Cillo, D. Estefania, J. Patron Uriburu, H. Ruiz, M. Salomon (Hospital Britanico de Buenos Aires).

Belarus: A. Makhmudov, L. Selnyahina, A. Varabei, Y. Vizhynis (Surgical Department of the Belarusian Medical Academy of Postgraduate Education).

Belgium: D. Claeys, B. Defoort, F. Muysoms, P. Pletinckx, V. Vergucht (AZ Maria Middelaes Gent); I. Debergh, T. Feryn, H. Reusens (AZ Sint-Jan); M. Nachtergaele (AZ St Jozef Malle); D. Francart, C. Jehaes, S. Markiewicz, B. Monami, J. Weerts (Clinique St Joseph, Liege); W. Bouckaert, B. Houben, J. Knol, G. Sergeant, G. Vangertruyden (Jessa Hospital Hasselt); L. Haeck, C. Lange, C. Sommeling, K. Vindevoghel (OLV van Lourdes Ziekenhuis); S. Castro, H. De Bruyn, M. Huyghe (St Augustinus General Hospital); E. De Wolf, D. Reynders (St Vincentius General Hospital); A. D'Hoore, A. de Buck van Overstraeten, A. Wolthuis (University Hospitals Leuven).

Bosnia and Herzegovina: S. Delibegovic (University Clinical Center Tuzla).

Brazil: A. Christiani, M. Marchiori Jr, C. Rocha de Moraes, V. Terciotti Jr (Centro Médico Campinas).

Bulgaria: E. Arabadjieva, D. Bulanov, D. Dardanov, V. Stoyanov, A. Yonkov (First Surgical Department, University Hospital Alexandrovska); K. Angelov, S. Maslyankov, M. Sokolov, G. Todorov, S. Toshev, (Second Surgery Clinic, Sofia Medical University). Y. Georgiev, A. Karashmalakov, G. Zafirov (Virgin Mary Hospital, Burgas).

China: X. Wang, (West China Hospital).

Croatia: D. Condic, D. Kraljik, H. Mrkovic, V. Pavkovic, K. Raguž (GCH Dr Josip Bencevic Slavonski Brod).

Czech Republic: V. Bencurik, E. Holášková, M. Skrovina (Hospital & Oncological Centre Nový Jičín); M. Farkašová, T. Grolich, Z. Kala (Masaryk University Hospital); F. Antos, V. Pruchova (Nemocnice Na Bulovce); O. Sotona, M. Chobola, T. Dusek, A. Ferko, J. Örhalmi (University Hospital Hradec Kralove); J. Hoch, P. Kocian, L. Martinek (University Hospital Motol).

Denmark: I. Bernstein, K. Gotschalck Sunesen, J. Leunbach, O. Thorlacius-Ussing, A. Uth Oveson (Aalborg University Hospital); P. Christensen, S. Dahl Chirstensen, V. Gamez, M. Oeting, U. Schou Loeve, A. Ugianskis (Randers Regional Hospital/Aarhus University Hospital); M. Jessen, P. Krarup, K. Linde (Bispebjerg Hospital); Q. Mirza, J. Overgaard Stovring (Esbjerg Hospital); L. Erritzøe, H. Loft Jakobsen, J. Lykke, E. Palmgren Colov (Herlev Hospital); A. Husted Madsen, T. Linde Friis (Herning Regional Hospital); J. Amstrup Funder, R. Dich (Hospitalsenheden Horsens); S. Kjær, S. Rasmussen, N. Schlesinger (Hvidovre Hospital); M. Dilling Kjaer, N. Qvist (OUH, Svendborg); A. Khalid (Regionshospitalet Viborg); G. Ali, A. El-Hussuna, S. Hadi, L. Rosell Walker (Slagelse Hospital).

Finland: A. Kivelä, T. Lehtonen, A. Lepistö, T. Scheinin, P. Siironen (Helsinki University Central Hospital); J. Kössi, P. Kuusanmäki, T. Tomminen, A. Turunen (Kanta-Häme Central Hospital); T. Rautio, M. Vierimaa (Oulu University Hospital); H. Huhtinen, J. Karvonen, M. Lavonius, A. Rantala, P. Varpe (Turku University Hospital).

France: E. Cotte, Y. Francois, O. Glehen, V. Kepenekian, G. Passot (Centre Hospitalier Lyon-Sud); L. Maggiori, G. Manceau, Y. Panis (CHU Beaujon); M. Gout (CHU Le Bocage); E. Rullier, B. van Geluwe (Hôpital Saint-André); N. Chafai, J. H. Lefevre, Y. Parc, E. Turet (Hôpital Saint-Antoine); C. Couette, E. Duchalais (University Hospital of Nantes).

Germany: A. Agha, M. Hornberger, A. Hungbauer, I. Iesalnieks, I. Weindl (Klinikum Bogenhausen); F. Crescenti (Klinikum Verden); M. Keller, N. Kolodziejewski, R. Scherer, D. Sterzing (Krankenhaus Waldriede); B. Bock, G. Boehm, M. El-Magd, C. Krones, M. Niewiera (Marienhospital Aachen); J. Buhr, S. Cordesmeier, M. Hoffmann, K. Krückemeier, T. Vogel (Raphaelsklinik Münster); M. Schön, J. Baral, T. Lukoschek, S. Münch, F. Pullig (Städtisches Klinikum Karlsruhe); K. Horisberger, P. Kienle, J. Magdeburg, S. Post (Universitätsmedizin).

Greece: K. Batzalexis, S. Germanos (General University Hospital of Larissa); C. Agalianos, C. Dervenis, N. Gouvas, P. Kanavidis, A. Kottikias (Konstantopouleio Hospital of Athens); I. E. Katsoulis, D. Korkolis, G. Plataniotis, G. Sakorafas (St. Savvas Cancer Hospital, Athens); I. Akrida, M. Argentou, C. Kollatos, C. Lampropoulos, S. Tsochatzis (University Hospital of Patras).

Hungary: I. Besznyák, A. Bursics, T. Egyed, G. Papp, I. Svastics (Uzsoki Hospital).

Iceland: J. Atladottir, P. Möller, H. Sigurdsson, T. Stefánsson, E. Valsdottir (The National University Hospital in Iceland).

Ireland: E. Andrews, N. Foley, D. Hechtel, M. Majeed, M. McCourt (Cork University Hospital); A. Hanly, J. Hyland, S. Martin, P. R. O'Connell, D. Winter (St Vincent's University Hospital); T. Connelly, W. Joyce, P. Wrafter (The Galway Clinic).

Israel: R. Berkovitz (Hadassah Medical Center); S. Avital, I. Haj Yahia, N. Hermann, B. Shpitz, I. White (Meir Medical Center); Y. Lishtzinsky, A. Tsherniak, N. Wasserberg (Rabin Medical Center, Beilinson Campus); N. Horesh, U. Keler, R. Pery, R. Shapiro, O. Zmora (Sheba Medical Centre); H. Tulchinsky (Tel Aviv Sourasky Medical Center); B. Badran, K. Dayan, A. Iskhakov, J. Lecaros, N. Nabih (Wolfson Medical Center).

Italy: I. Angrima, R. Bardini, E. Pizzolato, M. Tonello (Azienda Ospedaliera - Università degli Studi di Padova); F. Arces, R. Balestri, C. Ceccarelli, V. Prospero, E. Rossi (Azienda Ospedaliera Universitaria Pisana); I. Giannini, L. Vincenti (Azienda Ospedaliera Universitaria Policlinico Bari); F. Di Candido, M. Di Iena, A. Guglielmi, O. Caputi-Iambrenghi (Department of Emergency and Organ Transplantation, University of Bari); P. Marsanic, A. Mellano, A. Muratore (Candiolo Cancer Institute - FPO - IRCCS); M. Annetichiarico, L. Bencini, S. Amore Bonapasta, A. Coratti, F. Guerra (Careggi Hospital); C. R. Asteria, L. Boccia, L. Gerard, A. Pascariello (ASST - Mantova); G. Manca, F. Marino (Di Summa - Perrino Hospital); A. Casaril, M. Inama, G. Moretto (Hospital "Dott. Pederzoli" Peschiera del Garda - Verona); C. Bacchelli, M. Carvello, N. Mariani, M. Montorsi, A. Spinelli (Humanitas Research Hospital); E. Romairone, S. Scabini (IRCCS San Martino IST); A. Belli, F. Bianco, S. De Franciscis, G. Maria Romano (Istituto Nazionale dei Tumori, Napoli, Unità di Oncologia Addominale); P. Delrio, U. Pace, D. Rega, C. Sassaroli, D. Scala, (Istituto Nazionale Tumori Napoli); R. De Luca, E. Ruggieri (National Cancer Research Center Istituto "G. Paolo II" IRCCS-BARI); C. Elbetti, A. Garzi, L. Romoli, M. Scatizzi, A. Vannucchi (Ospedale S. Stefano); G. Curletti, V. Durante, R. Galleano, F. Mariani, L. Reggiani (Ospedale Santa Corona); R. Bellomo, A. Infantino (Ospedale Santa Maria dei Battuti); L. Franceschilli, P. Sileri (Policlinico di Tor Vergata); I. Clementi, D. Coletta, F. La Torre, A. Mingoli, F. Velluti (Policlinico Umberto I "La Sapienza" University of Rome); A. Di Giacomo, A. Fiorot, M. Massani, L. Padoan, C. Ruffolo (Regional Hospital Cà Foncello, Treviso); S. Caruso, F. Franceschini, R. Laessig, I. Monaci, M. Rontini (S.M. Annunziata Azienda Sanitaria Firenze 10); P. De Nardi, U. Elmore, M. Lemma, R. Rosati, A. Tamburini (San Raffaele Scientific Institute and Vita Salute University); M. De Luca, A. Sartori, (San Valentino Hospital); A.

Benevento, C. Bottini, C. C. Ferrari, F. Pata, G. Tessera (Sant'Antonio Abate Hospital, Gallarate); G. Pellino, F. Selvaggi (Second University of Naples); A. Lanzani, F. Romano, G. Sgroi, F. Steccanella, L. Turati (Treviglio Hospital).

Japan: T. Yamamoto (Yokkaichi Hazu Medical Centre).

Latvia: G. Ancans, S. Gerkis, M. Leja, A. Pcolkins, A. Sivins (Riga East University Hospital, Latvia Oncology Center);

Lithuania: T. Latkauskas, P. Lizdenis, Ž. Saladžinskas, S. Švagždys, A. Tamelis (Lithuanian University of Health Sciences, Faculty of Medicine, Department of Surgery); A. Razbadauskas, M. Sokolovas (Klaipeda Seamen's Hospital); A. Dulskas, N. Samalavicius (National Cancer Institute); V. Jotautas, S. Mikalauskas, E. Poskus, T. Poskus, K. Strupas (Vilnius University Hospital Santariskiu Klinikos).

Malta: C. Camenzuli, C. Cini, A. Predrag, J. Psaila, N. Spiteri (Mater Dei Hospital).

Netherlands: W. Bemelman, C. Buskens, E. J. de Groof, J. Gooszen, P. Tanis (Academic Medical Center Amsterdam); E. Belgers (Atrium Medical Center Heerlen); P. Davids, E. Furnee, E. Postma, A. Pronk, N. Smakman (Diaconessenhuis); S. Clermonts, D. Zimmermann (Elisabeth-Tweesteden); J. Omloo, E. van der Zaag P. van Duijvendijk, E. Wassenaar (Gelre Hospital Apeldoorn); M. Bruijninx, E. de Graff, P. Doornbosch, G. Tetteroo, M. Vermaas (IJsselland Ziekenhuis); G. Iordens, S. Knops, B. Toorenvliet (Ikazia Ziekenhuis); H. L. van Westereenen (Isala Hospital Zwolle); E. Boerma, P. Coene, E. van der Harst, A. Van Der Pool (Maasstad Ziekenhuis); M. Raber (Medisch Spectrum Twente Hospital); J. Melenhorst (MUMC+/AZM); S. de Castro, M. Gerhards (Onze Lieve Vrouwe Gasthuis); M. Arron, A. Bremers, H. de Wilt, F. Feren-schild, S. Yauw (Radboud University Medical Center); H. Cense, A. Demirkan, M. Hunfeld, I. Mulder (Rode Kruis Hospital); J. Nonner (Sint Franciscus Gasthuis); H. Swank, B. van Wagenveld (Sint Lucas Andreas Ziekenhuis); M. Bolmers, J. Briel, A. van Geloven, C. van Rossem (Tergooi Hospital Hilversum); V. Klemann, J. Konsten, B. Leenders, T. Schok (VieCuri Medical Center voor Noord-Limburg); W. Bleeker (Wilhelmina Hospital Assen).

Northern Ireland: A. Gidwani, R. Lawther, P. Loughlin, B. Skelly, R. Spence (Altnagelvin Hospital).

Norway: M. Brun, M. Helgeland, D. Ignjatovic, T. Øresland, P. Yousefi (Akershus University Hospital); I. Flåten Backe, O. Helmer Sjo, A. Nesbakken, M. Tandberg-Eriksen (Oslo University Hospital); A. Cais, J. Hallvard Træland, R. Herikstad, H. Kørner, N. Lauvland (Stavanger University Hospital).

Poland: D. Jajtner, W. Kabiesz, M. Rak (Beskidian Oncological Center); L. Gmerek, K. Horbacka, N. Horst, P. Krokowicz (General and Colorectal Surgery Department University of Medical Sciences); A. Kwiatkowski, K. Pasnik (Military Institute of Medicine); P. Karcz, M. Romaniszyn, T. Rusek, P. Walega (Third Department of General Surgery, Jagiellonian University Medical College); R. Czarencki, Z. Obuszko, M. Sitarska, W. Wojciech, M. Zawadzki (Wroclaw Regional Hospital).

Portugal: S. Amado, P. Clara, A. Couceiro, R. Malaquias, N. Rama (Centro Hospitalar de Leiria); A. Almeida, E. Barbosa, E. Cernadas, A. Duarte, P. Silva (Centro Hospitalar s. João); S. Costa, C. Martinez Insua, R. Marques, J. Pereira, C. Pereira, M. Sacchetti (Centro Hospitalar Tâmega e Sousa); B. Carvalho Pinto, P. Jorge Vieira Sousa, A. Oliveira (Centro Hospitalar Trás os Montes e Alto Douro); R. Cardoso, S. Carlos, J. Corte-Real, P. Moniz Pereira, R. Souto (Garcia de Orta); C. Carneiro, R. Marinho, V. Nunes, R. Rocha, M. Sousa (Hospital Prof.Dr. Fernando Fonseca); J. Leite, F. Melo, J. Pimentel, L. Ventura, C. Vila Nova (Universidade Coimbra).

Romania: C. Copăescu (Ponderas Hospital); V. Bintintan, C. Ciuce, G. Dindelegan, R. Scurtu, R. Seicean (Univeristy Emergency Hospital Cluj Napoca).

Russia: N. Domansky, A. Karachun, A. Moiseenko, Y. Pelipas, A. Petrov, I. Pravosudov (N.N.Petrov Research Institute of Oncology); R. Aiupov, Y. Akmalov, A. Parfenov, N. Suleymanov, N. Tarasov (Oncological Centre); H. Jumabaev, Z. Mamedli, A. Rasulov (Russian Cancer Research Center); I. Aliev, I. Chernikovskiy, V. Kochnev, K. Komyak, I. Pravosudov, A. Smirnov (St. Petersburg Clinical Research Center); S. Achkasov, K. Bolikhov, Y. Shelygin, O. Sushkov, A. Zapolskiy (State Scientific Center of Coloproctology).

Serbia: M. Gvozdenovic, D. Jovanovic, Z. Lausevic (Center of Emergency Surgery, Clinical Center of Serbia); D. Cvetković, M. Maravić, B. Milovanovic, N. Stojakovic, I. Tripković (City Hospital Valjevo); D. Mihajlovic, M. Nestorovic, V. Pecic, D. Petrovic, G. Stanojevic (Clinical Centre Nis); G. Barisic, I. Dimitrijevic, Z. Krivokapic, V. Markovic, M. Popovic (First Surgical Clinic, Cilinical Centre of Serbia, Belgrade); A. Aleksic, D. Dabic, I. Kostic, A. Milojkovic, V. Perunicic (General Hospital Cacak); D. Lukic, T. Petrovic, D. Radovanovic, Z. Radovanovic (Oncology Institute of Vojvodina); V. M. Cuk, V. V. Cuk, M. Kenic, B. Kovacevic, I. Krdzic (University Clinical Center Zvezdara).

Slovakia: J. Korcek (Teaching Hospital Nitra).

Slovenia: M. Rems, J. Toplak (General Hospital Jesenice).

Spain: J. Escarrà, M. Gil Barrionuevo, T. Golda, E. Kreisler Moreno, C. Zerpa Martin (Bellvitge University

Hospital); C. Álvarez Laso, P. Cumplido, H. Padin (Cabueñes); J. Baixauli Fons, J. Hernández-Lizoain, P. Martínez-Ortega, M. Molina-Fernández, C. Sánchez-Justicia (Clínica Universidad de Navarra); J. Antonio Gracia Solanas, E. Córdoba Díaz de Laspra, E. Echazarreta-Gallego, M. Elia-Guedea, J. Ramirez (Clínico Universitario, Zaragoza); J. Arredondo Chaves, P. Diez González, T. Elosua, J. Sahagún, A. Turienzo Frade (Complejo Asistencial Universitario de León); J. Álvarez Conde, E. Castrillo, R. Diaz Maag, V. Maderuelo, L. Saldarriaga (Complejo asistencial Universitario de Palencia); I. Aldrey Cao, X. Fernández Varela, S. Núñez Fernández, A. Parajó Calvo, S. Villar Álvarez (Complejo Hospitalario de Ourense); I. Blesa Sierra, A. Duarte, R. Lozano, M. Márquez, O. Porcel (Complejo Hospitalario Torrecárdenas); P. Menendez (Gutierrez Ortega); M. Fernández Hevia, L. Flores Sigüenza, M. Jimenez Toscano, A. Lacy Fortuny, J. Ordoñez Trujillo (Hospital Clínic de Barcelona); A. Espi, S. Garcia-Botello, J. Martín-Arévalo, D. Moro-Valdezate, V. Pla-Martí (Hospital Clínico Universitario de Valencia); F. Blanco-Antona (Hospital Clínico Universitario de Valladolid); J. Abrisqueta, N. Ibañez Canovas, J. Lujan Mompean (Hospital Clínico Universitario Virgen de la Arrixaca); D. Escolá Ripoll, S. Martinez Gonzalez, J. Parodi (Hospital Comarcal de Vilafranca); A. Fernández López, M. Ramos Fernández (Hospital Costa del Sol); J. Castellvi Valls, L. Ortiz de Zarate, R. Ribas, D. Sabia, L. Viso (Hospital de Sant Joan Despí Moisès Broggi); S. Alonso Gonçalves, M. José Gil Egea, M. Pascual Damietta, M. Pera, S. Salvans Ruiz (Hospital del Mar); J. Bernal, F. Landete (Hospital General de Requena); G. Ais, J. Etreros (Hospital General de Segovia); J. Aguiló Lucia, A. Boscá, S. Deusa, J. García del Caño, V. Viciano (Hospital Lluís Alcanyís); J. García-Armen-gol, J. Roig (Hospital NISA 9 de Octubre); J. Blas, J. Escartin, J. Fatás, J. Fernando, R. Ferrer (Hospital Royo Villanova); R. Arias Pacheco, L. García Flórez, M. Moreno Gijón, J. Otero Díez, L. Solar Garcia (Hospital San Agustín); F. Aguilar Teixido, C. Balaguer Ojo, J. Bargarro Berzosa, S. Lamas Moure (Hospital Terrassa); J. Enrique Sierra, A. Fermián, F. Herrerias, M. Rufas, J. Viñas (Hospital Universitari Arnau de Vilanova); A. Codina-Cazador, R. Farrés, N. Gómez, D. Julià, P. Planellas (Hospital Universitari de Girona Doctor Josep Trueta); J. López, A. Luna, C. Maristany, A. Muñoz Duyos, N. Puértolas (Hospital Universitari Mútua Terrassa); M. Alcantara Moral, X. Serra-Aracil (Hospital Universitari Parc Taulí de Sabadell); P. Concheiro Coello, D. Gómez (Hospital Universitario de A Coruña); C. Carton, A. Miguel, F. Reoyo Pascual, X. Valero Cer-rato, R. Zambrano Muñoz (Hospital Universitario de

Burgos); J. Cervera-Aldama, J. García González, J. Ramos-Prada, M. Santamaría-Olabarrieta, A. Urigüen-Echeverría (Hospital Universitario de Cruces); R. Coves Alcover, J. Espinosa Soria, E. Fernandez Rodriguez, J. Hernandis Villalba, V. Maturana Ibañez (Hospital Universitario De Elda); F. De la Torre Gonzalez, D. Huer-ga, E. Pérez Viejo, A. Rivera, E. Ruiz Ucar (Hospital Universitario de Fuenlabrada); J. Garcia-Septiem, V. Jiménez, J. Jiménez Miramón, J. Ramons Rodriguez, V. Rodríguez Alvarez (Hospital Universitario de Getafe); A. Garcea, L. Ponchiatti (Hospital Universitario de Torre-veja); N. Borda, J. Enriquez-Navascues, Y. Saralegui (Hospital Universitario Donostia); G. Febles Molina, E. Nogues, Á. Rodríguez Méndez, C. Roque Castellano, Y. Sosa Quesada (Hospital Universitario Dr Negrín); M. Alvarez-Gallego, I. Pascual, I. Rubio-Perez, B. Diaz-San Andrés, F. Tone-Villanueva (Hospital Universitario La Paz); J. Alonso, C. Cagigas, J. Castillo, M. Gómez, J. Martín-Parra (Hospital Universitario Marqués de Valde-cilla); M. Mengual Ballester, E. Pellicer Franco, V. Soria Aledo, G. Valero Navarro (Hospital Universitario Morales Meseguer); E. Caballero Rodríguez, P. Gonzalez De Chaves, G. Hernandez, A. Perez Alvarez, A. Soto Sanchez, (Hospital Universitario Ntra Sra de Candelaria); F. Cesar Becerra Garcia, J. Guillermo Alonso Roque, F. López Rodríguez Arias, S. R. Del Valle Ruiz, G. Sánchez De La Villa (Hospital Universitario Rafael Méndez); A. Compañ, A. García Marín, C. Nofuentes, F. Orts Micó, V. Pérez Auladell (Hospital Universitario San Juan de Alicante); M. Carrasco, C. Duque Perez, S. Gálvez-Pas-tor, I. Navarro Garcia, A. Sanchez Perez (Hospital Universitario Santa Lucía); D. Enjuto, F. Manuel Bujal-ance, N. Marcelin, M. Pérez, R. Serrano García (Hospita-l Universitario Severo Ochoa); A. Cabrera, F. de la Portilla, J. Diaz-Pavon, R. Jimenez-Rodriguez, J. Vaz-quez-Monchul (Hospital Universitario Virgen del Rocío); J. Daza González, R. Gómez Pérez, J. Rivera Castellano, J. Roldán de la Rua (Hospital Virgen de la Victoria); J. Errasti Alustiza, L. Fernandez, J. Romeo Ramirez, J. Sardon Ramos, B. Cermeño Toral (Hospital Universitario Araba); D. Alias, D. Garcia-Olmo, H. Guadalajara, M. Herreros, P. Pacheco (Quironsalud); F. del Castillo Díez F. Lima Pinto, J. Martínez Alegre, I. Ortega, A. Picardo Nieto Antonio (Infanta Sofia Univer-sity Hospital); A. Caro, J. Escuder, F. Feliu, M. Millan (Joan XXIII University Hospital); R. Alos Company, A. Frangi Caregnato, R. Lozoya Trujillo, R. Rodríguez Carrillo, M. Ruiz Carmona (Sagunto); N. Alonso, D. Ambrona Zafra, B. Amilka Ayala Candia J. Bonnin Pascual, C. Pineño Flores (Son Espases); J. Alcazar Mon-tero, M. Angoso Clavijo, J. Garcia, J. Sanchez Tocino (Universitario de Salamanca); C. Gómez-Alcazar, D.

Costa-Navarro, J. Ferri-Romero, M. Rey-Riveiro, M. Romero-Simó (University General Hospital of Alicante); B. Arencibia, P. Esclapez, M. Frasson, E. García-Granero, P. Granero (University Hospital La Fe); F. J. Medina Fernández, A. B. Gallardo Herrera, C. Diaz López, E. Navarro Rodriguez, E. Torres Tordera (University Hospital Reina Sofia de Córdoba); J. Arenal, M. Citores, J. Marcos, J. Sánchez, C. Tinoco (University Hospital Río Hortega); E. Espin, A. García Granero, L. Jimenez Gomez, J. Sanchez Garcia, F. Vallribera (Valle de Hebron).

Sweden: J. Folkesson, F. Sköldberg (Akademiska Sjukhuset); K. Bergman, E. Borgström, J. Frey, A. Silfverberg, M. Söderholm (Blekingesjukhuset); J. Nygren, J. Segelman (Karolinska Institutet and Ersta Hospital); D. Gustafsson, A. Lagerqvist, A. Papp, M. Pelczar (Hudiksvalls Hospital); M. Abraham-Nordling, M. Ahlberg, A. Sjoval (Karolinska University Hospital); J. Tengstrom (Lidköping); K. Hagman (Ryhov County Hospital); A. Chabok, E. Ezra, M. Nikberg, K. Smedh, C. Tiselius (Västmanlands Hospital Västerås).

Switzerland: N. Al-Naimi, M. Dao Duc, J. Meyer, M. Mormont, F. Ris (Geneva University Hospitals); G. Prevost, P. Villiger (Kantonsspital Graubünden); H. Hoffmann, C. Kettelhack, P. Kirchhoff, D. Oertli, B. Weixler (University Hospital Basel).

Turkey: B. Aytac, S. Leventoglu, B. Mentos, O. Yuksel (Gazi University Medical School, Dep. of Surg); S. Demirbas (Gülhane Military Medical Academy, School of Medicine); B. Busra Ozkan, G. Selçuk Özbacı (Ondokuz Mayıs University Medical Faculty); U. Sunгурtekin (Pamukkale University School of Medicine); B. Gülcü, E. Ozturk, T. Yilmazlar (Uludag University School of Medicine Hospital).

UK: C. Challand, N. Fearnhead, R. Hubbard, S. Kumar (Addenbrooke's Hospital); J. Arthur, C. Barben, P. Skaife, S. Slawik, M. Williams (Aintree University Hospitals NHS Foundation Trust); M. Zammit (Basilston Hospital); J. Barker, J. French, I. Sarantitis, C. Slawinski (Blackpool Victoria); R. Clifford, N. Eardley, M. Johnson, C. McFaul, D. Vimalachandran (Countess of Chester); S. Allan, A. Bell, E. Oates, V. Shanmugam (Darlington Memorial Hospital); A. Brigic (Doncaster Royal Infirmary); M. Halls, P. Pucher, B. Stubbs (Dorset County Hospital); T. Agarwal, A. Chopada, S. Mallappa, M. Pathmarajah, C. Sugden (Ealing Hospital); C. Brown, E. Macdonald, A. Mckay, J. Richards, A. Robertson (Forth Valley Royal Hospital); M. Kaushal, P. Patel, S. Tezas, N. Touqan (Furness General Hospital); S. Ayaani, K. Marimuthu, B. Piramanayagam, M. Vourvachis (George Eliot Hospitals NHS Trust); N. Iqbal, S. Korsgen, C. Seretis, U. Shariff (Good Hope Hospital); S. Arnold, N. Battersby, H. Chan, E. Clark, R. Fernandes, B. Moran (Hampshire Hospitals NHS

Trust); A. Bajwa, D. McArthur (Heartlands Hospital); K. Cao, P. Cunha, H. Pardoe, A. Quddus, K. Theodoropoulou (Homerton Hospital); C. Bolln, G. Denys, M. Gillespie, N. Manimaran, J. Reidy (Inverclyde Royal Hospital); A. I. Malik, A. Malik, J. Pitt (Ipswich Hospital NHS Trust); K. Aryal, A. El-Hadi, R. Lal, A. Pal, V. Velchuru (James Paget University Hospital); S. Chaudhri, M. Oliveira Cunha, B. Singh, M. Thomas (Leicester General Hospital); S. Bains, K. Boyle, A. Miller, M. Norwood, J. Yeung (Leicester Royal Infirmary); L. Goian, S. Gurjar, W. Saghir, N. Sengupta, E. Stewart-Parker (Luton & Dunstable Hospital); S. Bailey, T. Khalil, D. Lawes, S. Nikolaou, G. Omar (Maidstone and Tunbridge Wells NHS Trust); R. Church, B. Muthiah (Manor Hospital); W. Garrett, P. Marsh, N. Obeid (Medway Maritime Hospital); S. Chandler, P. Coyne, M. Evans (Morriston Hospital); L. Hunt, J. Lim, Z. Oliphant, E. Papworth, H. Weaver, (Musgrove Park Hospital); K. Cuiñas Leon, G. Williams, (New Cross Hospital); J. Hernon, S. Kapur, R. Moosvi, I. Shaikh, L. Swafe (Norfolk and Norwich University Hospital); M. Aslam, J. Evans, U. Ihedioha, P. Kang, J. Merchant (Northampton General Hospital); R. Hompes, R. Middleton (Oxford University Hospitals); A. Broomfield, D. Crutten-Wood, J. Foster, G. Nash (Poole General Hospital); M. Akhtar, M. Boshnaq, S. Eldesouky, S. Mangam, M. Rabie (QEQM Hospital, EKHUF Trust); J. Ahmed, J. Khan, N. Ming Goh, A. Shamali, S. Stefan (Queen Alexandra Hospital); D. Nepogodiev, T. Pinkney, C. Thompson (Queen Elizabeth Hospital Birmingham); A. Amin, J. Docherty, M. Lim, K. Walker, A. Watson (Raigmore Hospital); M. Hossack, N. Mackenzie, M. Paraoan (Royal Albert Edward Infirmary); N. Alam, I. Daniels, S. Narang, S. Pathak, N. Smart (Royal Devon and Exeter Hospital); A. Al-Qaddo, R. Codd, O. Rutka, G. Williams, (Royal Gwent Hospital); C. Bronder, I. Crighton, E. Davies, T. Raymond (Royal Lancaster Infirmary); L. Bookless, B. Griffiths, S. Plusa (Royal Victoria Infirmary); G. Carlson, R. Harrison, N. Lees, C. Mason, J. Quayle (Salford Royal NHS Foundation Trust); G. Branagan, J. Broadhurst, H. Chave, S. Sleight (Salisbury District Hospital); F. Awad, A. Bhangu, N. Cruickshank, H. Joy (Sandwell General Hospital); C. Boereboom, P. Daliya, A. Dhillon, N. Watson, R. Watson (Sherwood Forest Hospitals NHS Foundation Trust); D. Artioukh, K. Gokul, M. Javed, R. Kong, J. Sutton (Southport & Ormskirk Hospital); O. Faiz, I. Jenkins, C. A. Leo, S. F. Samaranyake, J. Warusavitarne (St Mark's Hospital); S. Arya, C. Bhan, H. Mukhtar, A. Oshowo, J. Wilson (The Whittington Hospital); S. Duff, T. Fatayer, J. Mbuvu, A. Sharma (University Hospital of South Manchester NHS Trust); J. Cornish, L. Davies, R.

Harries, C. Morris, J. Torkington (University Hospital of Wales); J. Knight, C. Lai, O. Shihab, A. Tzivanakis (University Hospital Southampton); A. Hussain, D. Luke, R. Padwick, A. Torrance, A. Tsiamis (University Hospitals of North Midlands); P. Dawson (West Middlesex University Hospital); A. Balfour, R. Brady, J. Mander, H. Paterson (Western General Hospital); N. Chandratreya, H. Chu, J. Cutting, S. Vernon, C. Wai Ho (Weston General Hospital); S. Andreani, H. Patel,

M. Warner, J. Yan Qi Tan (Whipps Cross University Hospital).

USA: A. Iqbal, A. Khan, K. Perrin, A. Raza, S. Tan (University Hospital of Florida).

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