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Perforated diverticulitis in the North of England: trends in patient outcomes, management approach and the influence of subspecialisation

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ABSTRACT

INTRODUCTION In recent years, several management options have been used in the management of perforated diverticulitis, ranging from conservative treatment to laparotomy. General surgery has also become increasingly specialised over time. This retrospective cohort study investigated changes in patient outcomes following perforated diverticulitis, management approach and the influence of consultant subspecialisation over time.

MATERIALS AND METHODS Data was collected on patients admitted with perforated diverticulitis in the North of England between 2002 and 2016. Subspecialisation was categorised as colorectal or other general subspecialties. The primary outcome of interest was overall 30-day mortality; secondary outcomes included surgical approach, stoma and anastomosis rate.

RESULTS A total of 3394 cases of perforated diverticulitis were analysed (colorectal, n = 1290 and other subspecialists, n = 2104) with a 30-day mortality of 11.6%. There was a significant reduction in mortality over time (2002–2006: 18.6% to 2012–2016: 6.8, $P < 0.001$).

There was a significant reduction in open surgery (60% to 25.3%, $P < 0.001$) with increased conservative management (37.4% to 63.5%, $P < 0.001$), laparoscopic resection (0.1% to 4.9%, $P < 0.001$) and laparoscopic washout (0.1% to 5.7%, $P < 0.001$).

Patients admitted under colorectal surgeons had lower mortality than other subspecialists (9.9% vs 12.4%, $P = 0.027$), which remained significant following multivariate adjustment (hazard ratio 1.44, $P = 0.039$). These patients had fewer stomas (13.9% vs. 21.0%, $P = 0.001$) and higher anastomosis rates (22.1% vs 15.8%, $P = 0.004$).

CONCLUSION This study demonstrated considerable improvements in the management of perforated diverticulitis alongside the positive impact of subspecialisation on patient outcomes.

KEYWORDS
Perforated diverticulitis – Outcomes – Management; Subspecialty – Subspecialisation

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Introduction

Diverticular disease is a common pathology whose prevalence is increasing throughout the world.[1] While the majority of patients remain asymptomatic, diverticulitis and its associated complications can result in significant morbidity and mortality. The most severe presentation of diverticulitis is perforation.

Perforated diverticulitis encompasses a broad spectrum of disease, from localised perforation through to faecal peritonitis. Traditionally, the Hinchey classification was the most widely used grading system for perforated diverticulitis.[2] Conventional thought was that, while cases of localised perforation (Hinchey I and II) can be managed conservatively or with percutaneous drainage, more severe cases with generalised peritonitis (Hinchey III or IV) necessitated emergency surgery,[1] most commonly in the form of resection and end colostomy (Hartmann's procedure). A number of recent studies have assessed the efficacy of less invasive management for more severe cases of perforated diverticulitis. In cases of perforated diverticulitis with pneumoperitoneum, studies have reported good outcomes with non-operative management.[3–6] Laparoscopic lavage has also been compared with primary resection, for cases of generalised purulent peritonitis (Hinchey III) across a number of meta-analyses.[7–10] While some have shown favourable results for laparoscopic lavage,[7] others have been inconclusive.[8–10] Further debate exists as to whether a primary anastomosis should be performed in cases of generalised peritonitis (Hinchey III or IV). While the results of two published trials favoured primary anastomosis,[12,13] the evidence base for this remains inconclusive.[14]

Subspecialist colorectal surgeons are more likely than other general surgeons to form a primary anastomosis for perforated diverticulitis in the emergency setting.[15–17] The third National Emergency Laparotomy Audit (NELA) report highlights that, while colorectal surgeons perform the highest proportion of emergency laparotomies, many other subspecialists still contribute towards emergency on-call rotas.[18] There is a paucity of research considering the impact of consultants' subspecialties within emergency colorectal surgery. Boyce *et al* saw that the formation and centralisation of a subspecialist colorectal surgery unit led to a significant reduction in operative mortality, increased anastomosis rate and reduced stoma rate.[17] Similar findings were described by Biondo *et al* across all emergency colorectal resection.[16] Subspecialist management of emergency surgical admissions is far from common practice however, and more work is needed to establish whether this could improve patient outcomes.

The aim of this study was to evaluate trends in management approach and outcomes for patients with perforated diverticulitis across NHS hospitals in the North of England over a 15-year period. We also assessed how management was influenced by surgical subspecialisation.

Materials and methods

Data were requested for patients admitted with perforated diverticulitis in all acute NHS foundation trusts in the North of England. Caldicott approval was sought and patient data anonymised before being provided to the authors. This information was derived from hospital episode statistics in each trust.[19] Data were requested for all emergency admissions under a general surgeon between 1 January 2002 and 31 December 2016. Data fields that were obtained are detailed in Appendix 1 (available online). The data provided enabled calculation of age at admission, day of admission, season of admission, duration of hospital stay, time to procedure from admission, day of procedure and day of in-hospital death. Patients with perforated diverticulitis were identified with the International Classification of Diseases and Related Health Problems, 10th Revision (ICD-10) codes of K57.2, K57.4 and K57.8. Admissions with missing patient characteristics or 30-day in-hospital mortality (0.54% of 490,380 cases) were excluded from the analysis.

Data definitions

The study population included all patients aged 18 years or older admitted as an emergency under a general surgeon in hospitals in the North of England. Calculation of deprivation scores was achieved by conversion of postal codes to Index of Multiple Deprivations scores using the validated online conversion tool.[20] ICD-10 diagnostic codes were used to identify relevant comorbidities, which were mapped and converted to Charlson scores using the using weightings employed by the hospital standardised mortality ratio.[21–24] To account partially for the severity of patients' illnesses, a clinical risk grouping was generated by assigning patients' primary ICD-10 diagnosis to 1 of 259 diagnostic groups using the Clinical Classification software.[25] These diagnostic groups were ranked into three equally sized groups based on the 30-day crude in-hospital mortality rates. Primary procedure data were also used to account for any further differences in case mix by additionally adjusting for quartile of risk of procedure in the same manner. Weekends were defined as Saturday, Sunday or a bank holiday. Weekdays were defined as Monday to Friday. Patients were categorised into three discrete five-year groups for analysis of trends over time (2002–2006, 2007–2011, and 2012–2016). The responsible consultant for the relevant hospital spell was provided in the dataset. The subspecialty practised by the consultant during the relevant study period was identified from NHS and subspecialty society websites.[26–28] Two categories, colorectal subspecialists and 'other general subspecialists', were generated for subspecialty analysis, where 'other general subspecialists' consisted of non-colorectal consultants undertaking emergency general surgery, including upper gastrointestinal, breast, vascular and other general surgeons. Trust size was categorised by hospital bed capacity into small/medium or large/very large according to NELA-defined quartiles.[29]

Management strategies were divided into six groups for analysis: conservative (non-procedural), percutaneous drainage, laparoscopic washout (no resection), laparoscopic resection, laparotomy and resection, and laparotomy without resection. The OPCS classification of interventions and procedures version 4 codes (OPCS-4) that were used to identify procedure type are outlined in Appendix 2 (available online). The primary outcome of interest was in-hospital death within 30 days of admission for conservatively managed patients and 30 days of procedure for patients who underwent any form of operative intervention (including percutaneous drainage and laparoscopic washout). Secondary outcomes included: hospital length of stay, rate of stoma formation, anastomosis and bowel resection. OPCS-4 codes used to identify stoma formation and anastomoses are outlined in Appendix 2 (available online).

Statistical analysis

These retrospective observational data were collected in Microsoft Excel 2010 and analyses were undertaken using Stata® 13.1 software (StataCorp, College Station, TX). Categorical data were summarised using frequencies and percentages, and continuous data using the mean with its 95% confidence interval. These groups were compared using Pearson's chi squared test for trend for categorical variables, and analysis of variance with post hoc testing for continuous variables. The factors associated with 30-day in-hospital death were determined using a Cox regression model with a time-dependent covariable to describe the hazards associated with admissions with perforated diverticulitis. Factors with P-value less than 0.200 in the univariable models were entered into multivariable models. The multivariable models were built by inclusion of variables that achieved P-value less than 0.050 and significant improvement of model fit (reduction in Akaike's

Information Criterion of at least 4).[30,31] Statistical significance was defined in all analyses as P-value less than 0.050.

Results

Change in patient characteristics over time

A total of 3394 cases of perforated diverticulitis were analysed (850 patients in 2002–2006, 1124 in 2007–2011 and 1420 in 2012–2016). A decrease in mean age was observed over time (2002–2006: 66.6 to 2012–2016: 63.5, $P < 0.001$), alongside a consistent female predominance. There was a significant decrease in clinical ($P < 0.001$) risk grouping across the study period, with patients increasingly presenting through accident and emergency rather than general practice ($P < 0.001$; Table 1).

Change in management and patient outcomes over time

Patient mortality significantly decreased over the study period from 18.6% in 2002–2006 to 6.8% in 2012–2016 ($P < 0.001$; Table 2). This remained true following adjustment for other covariates with multivariate regression analysis (2002–2006: hazard ratio, HR, 1.00 vs 2012–2016: HR 0.51, $P < 0.001$; Appendix 6, available online). Overall length of stay also decreased from 21.6 days to 13.7 days, respectively ($P < 0.001$). Operative approach varied significantly over the 15-year study period, with a significant reduction in the number undergoing open surgery (2002–2006: 60% to 2012–2016: 25.3%, $P < 0.001$) and consequent rise in alternative management strategies. There was a significant increase in conservative management (37.4% to 63.5%, $P < 0.001$), laparoscopic resection (0.1% to 4.9%, $P < 0.001$) and laparoscopic washout (0.1% to 5.7%, $P < 0.001$). Of

Table 1 Baseline characteristics of patients presenting with perforated diverticulitis, by study period.

Characteristic	Study period				*P*-value
	2002–2006 (*n* = 850)	**2007–2011 (*n* = 1124)**	**2012–2016 (*n* = 1420)**	**Overall (*n* = 3394)**	
Age (years) mean (95% CI)[a]	66.6 (65.6–67.6)	65.2 (64.3–66.1)	63.5 (62.7–64.3)	64.8 (64.3–65.3)	<0.001
Sex, *n* (%):					0.048
Male	341 (40.1)	500 (44.5)	568 (40.0)	1409 (41.5)	
Female	509 (59.9)	624 (55.5)	852 (60.0)	1985 (58.5)	
Charlson score, *n* (%):					0.016
0–1	707 (83.2)	899 (80.0)	1151 (81.1)	2757 (81.2)	
2–4	121 (14.2)	195 (17.3)	207 (14.6)	523 (15.4)	
≥ 5	22 (2.6)	30 (2.7)	62 (4.4)	114 (3.4)	
Deprivation score, *n* (%):					0.017
1 (most)	175 (25.7)	192 (20.3)	272 (22.8)	639 (22.7)	
2	177 (26.0)	247 (26.2)	257 (21.5)	681 (24.2)	
3	123 (18.1)	180 (19.1)	224 (18.8)	527 (18.7)	
4	74 (10.9)	129 (13.7)	183 (15.3)	386 (13.7)	
5 (least)	131 (19.3)	196 (20.8)	257 (21.5)	584 (20.7)	
Clinical risk group, *n* (%):					< 0.001
1 (lowest)	105 (12.4)	140 (12.5)	168 (11.8)	413 (12.2)	
2	554 (65.2)	817 (72.7)	1145 (80.6)	2516 (74.1)	
3 (highest)	191 (22.5)	167 (14.9)	107 (7.5)	465 (13.7)	
Operative risk group, *n* (%):					0.003
1 (lowest)	89 (16.7)	101 (17.6)	76 (14.6)	266 (16.4)	
2	78 (14.7)	107 (18.6)	114 (22.0)	299 (18.4)	
3	231 (43.4)	270 (47.0)	219 (42.2)	720 (44.3)	
4 (highest)	134 (25.2)	97 (16.9)	110 (21.2)	341 (21.0)	
Admission method, *n* (%):					< 0.001
A&E	318 (37.4)	625 (55.6)	876 (63.9)	1819 (54.4)	
GP	375 (44.1)	346 (30.8)	265 (19.3)	986 (29.5)	

Table 1 (Continued)

Consultant clinic	18 (2.1)	25 (2.2)	50 (3.6)	93 (2.8)	
Other	139 (16.4)	128 (11.4)	180 (13.1)	447 (13.4)	
Trust size, *n* (%):					< 0.001
Small/medium	371 (43.6)	559 (49.7)	772 (54.4)	1702 (50.1)	
Large/very large	479 (56.4)	565 (50.3)	648 (45.6)	1692 (49.4)	
Season, *n* (%):					0.538
Spring	223 (26.2)	285 (25.4)	357 (25.1)	865 (25.5)	
Summer	223 (26.2)	317 (28.2)	358 (25.2)	898 (26.5)	
Autumn	206 (24.2)	278 (24.7)	353 (24.9)	837 (24.7)	
Winter	198 (23.3)	244 (21.7)	352 (24.8)	794 (23.4)	
Day of admission, *n* (%):					0.787
Weekday	650 (76.5)	868 (77.2)	1080 (76.1)	2598 (76.5)	
Weekend/bank holiday	200 (23.5)	256 (22.8)	340 (23.9)	796 (23.5)	
Day of surgery, *n* (%):					0.349
Weekday	378 (78.3)	458 (79.9)	447 (76.4)	1283 (78.2)	
Weekend/bank holiday	105 (21.7)	115 (20.1)	138 (23.6)	358 (21.8)	

Percentages and proportions were derived by excluding missing data from the variable. Chi square test for difference.
[a] analysis of variance.
A&E, accident and emergency department; CI, confidence interval; GP, general practitioner.

those who underwent a resection, there was no change in stoma rate (P = 0.486) or anastomosis rate (P = 0.051) over time (Table 2). Patients who underwent laparoscopic procedures were more than five years younger on average ($P < 0.001$) and had fewer comorbidities ($P = 0.003$; Appendix 3, available online). Patients who had laparoscopic procedures had the lowest 30-day mortality (washout 2.8% and resection 5.3%) with open operation the highest (resection 13.6% and no resection 23.3%, $P < 0.001$; Appendix 4, available online). They were also less likely to have a stoma ($P = 0.005$). Patients who underwent open operations had the longest length of stay (resection 22.1 days and no resection 24.0 days), with laparoscopic washout the shortest (9.5 days, $P < 0.001$).

Following multivariate Cox regression, increasing age, Charlson score (comorbidity), clinical risk group and operative risk group, with admission on a weekend/bank holiday, were identified as independent predictors of 30-day mortality (Appendix 6, available online).

Effect of consultant specialty on management and patient outcomes

An increasing number of patients were managed by a colorectal subspecialist (2002–2006: 27.1% to 2012-16: 46.3%, $P < 0.001$; Appendix 5, available online). There was no significant difference in age, sex, Charlson score or clinical risk group between patients based on the subspecialty of the responsible consultant. However, patients under other general subspecialties were in a higher operative risk group ($P < 0.001$). Patients under a colorectal subspecialist had a significantly lower overall 30-day mortality than their other general surgical colleagues (9.9% vs 12.4%, $P = 0.027$; Table 3). Multivariate regression confirmed that management by a colorectal subspecialist is an independent predictor of improved 30-day mortality (colorectal: HR 1.00 vs other subspecialists: HR 1.44, $P = 0.039$; Appendix 6, available online). Colorectal subspecialists used percutaneous drains ($P < 0.001$) and laparoscopy with washout ($P = 0.021$) more frequently than their colleagues. Primary open resection was more commonly performed by other general surgeons ($P = 0.021$). When focusing on patients who underwent an open operation or laparoscopic resection, colorectal surgeons were also more likely to form a primary anastomosis (22.1% vs. 15.8%, $P = 0.004$) and less likely to form a stoma (21.0% vs. 13.9%, $P = 0.001$; Table 3).

Discussion

This study has shown a significant decline in mortality for patients with perforated diverticulitis over the past 15 years in the North of England. Patients presenting with perforated diverticulitis in 2012–2016 were almost half as likely to die when compared with patients in 2002–2006 and were also spending a significantly shorter time in hospital. These improvements are in keeping with the wider trends seen within emergency surgery,[18,32] and it is likely that many factors have contributed towards this change. The high mortality seen in emergency general surgery has led to increasing focus and drive for improvement, not only in operative practice, but also in peri- and postoperative care.[18]

Less invasive management strategies are increasingly used in perforated diverticulitis. The number of patients undergoing an open operation has decreased considerably

Table 2 Operative approach and patient outcomes for patients with perforated diverticulitis, comparing differences over time.

	Study period				*P*-value
	2002–2006 (*n* = 850)	**2007–2011 (*n* = 1124)**	**2012–2016 (*n* = 1420)**	**Overall (*n* = 3394)**	
Operative approach, *n* (%):					
Open resection	464 (54.6)	460 (40.9)	344 (24.2)	1268 (37.4)	< 0.001
Open – no resection	46 (5.4)	29 (2.6)	15 (1.1)	90 (2.7)	< 0.001
Laparoscopy with washout	1 (0.1)	27 (2.4)	81 (5.7)	109 (3.2)	< 0.001
Laparoscopic resection	0 (0.0)	10 (0.9)	47 (3.3)	57 (1.7)	< 0.001
Conservative	318 (37.4)	549 (48.8)	901 (63.5)	1768 (52.1)	< 0.001
Percutaneous drain	21 (2.5)	49 (4.4)	32 (2.3)	102 (3.0)	0.005
Overall 30-day mortality					
Deaths, *n* (%)	158 (18.6)	135 (12.0)	96 (6.8)	389 (11.5)	< 0.001
30-day mortality by operative approach, *n* (%):					
Open resection	83 (17.9)	54 (11.7)	36 (10.5)	173 (13.6)	0.003
Open – no resection	14 (30.4)	4 (13.8)	3 (20.0)	21 (23.3)	0.239
Laparoscopy with washout	0 (0.0)	0 (0.0)	3 (3.7)	3 (2.8)	0.587
Laparoscopic resection	n/a	1 (10.0)	2 (4.3)	3 (5.3)	0.460
Conservative	59 (18.6)	70 (12.8)	50 (5.5)	179 (10.1)	< 0.001
Percutaneous drain	2 (9.5)	6 (12.2)	2 (6.3)	10 (9.8)	0.674
Length of hospital stay, mean days (95% CI):[a]	21.6 (19.8–23.4)	17.1 (15.9–18.4)	13.7 (12.8–14.5)	16.8 (16.1–17.5)	< 0.001
Stoma, *n* (%):[b]					0.486
No	83 (17.9)	77 (16.4)	58 (14.8)	218 (16.5)	
Yes	381 (82.1)	393 (83.6)	333 (85.2)	1107 (83.5)	
Anastomosis, *n* (%):[b]					0.051
No	364 (78.4)	394 (83.8)	328 (83.9)	1086 (82.0)	
Yes	100 (21.6)	76 (16.2)	63 (16.1)	239 (18.0)	

Percentages and proportions were derived by excluding missing data from the variable. Chi square test for difference. CI, confidence interval.
[a] Analysis of variance.
[b] Values calculated from patients who underwent an open resection or laparoscopic resection; patients who underwent another management approach excluded.

between 2002–2006 (60.0%) and 2012–2016 (25.3% $P < 0.001$). We also observed a significant increase in the number of patients undergoing conservative treatment (2002–2006 37.4%, 2012–16 63.5%, $P < 0.001$). This is in keeping with a growing body of evidence demonstrating that even severe cases of perforated diverticulitis can be managed conservatively.[7–10] Over the studied time period, the number of patients with perforated diverticulitis steadily increased. Rather than attributing these figures to increasing incidence, this is probably reflective of improved imaging availability. There is good evidence to show the increased availability and use of computed tomography in hospital,[33,34] which is likely to lead to increased detection of more minor perforations that may otherwise not have been diagnosed. Our results highlighted significant increases in the use of laparoscopic washout ($P < 0.001$) and resection ($P < 0.001$). However, as a proportion of the overall cohort, this group remained relatively small (2002–2006: 0.1%, 2012–2016: 9%) Good evidence has been reported for the potential benefits of laparoscopic colorectal surgery in the emergency setting.[35] The increase in use of laparoscopic lavage is perhaps more surprising, given that efficacy of the procedure continues to be a contentious issue.[7–10]

We identified that patients who underwent a laparoscopic, rather than an open procedure had an improved mortality and reduced length of hospital stay. They were

Table 3 Operative approach and patient outcomes for patients with perforated diverticulitis, comparing consultant subspecialty.

	Consultant subspecialty			
	Colorectal (*n* = 1291)	**Other (*n* = 2103)**	**Overall (*n* = 3394)**	***P*-value**
Operative approach, *n* (%):				
Open resection	450 (34.9)	818 (38.9)	1268 (37.4)	0.021
Open – no resection	40 (3.1)	50 (2.4)	90 (2.7)	0.204
Laparoscopy with washout	53 (4.1)	56 (2.7)	109 (3.2)	0.021
Laparoscopic resection	26 (2.0)	31 (1.5)	57 (1.7)	0.235
Conservative	665 (51.5)	1103 (52.4)	1768 (52.1)	0.595
Percutaneous drain	57 (4.4)	45 (2.1)	102 (3.0)	< 0.001
Overall 30-day	128 (9.9)	261 (12.4)	389 (11.5)	0.027
30-day mortality by operative approach, *n* (%):				
Open	56 (12.4)	117 (14.3)	173 (13.6	0.356
Open – no resection	4 (10.0)	17 (34.0)	21 (23.3)	0.007
Laparoscopy with washout	2 (3.8)	1 (1.8)	3 (2.8)	0.526
Laparoscopic resection	2 (7.7)	1 (3.2)	3 (5.3)	0.452
Conservative	57 (8.6)	122 (11.1)	179 (10.1)	0.093
Percutaneous drain	7 (12.3)	3 (6.7)	10 (9.8)	0.344
Mortality, *n* (%):				
2002–2006	36 (15.7)	122 (19.7)	158 (18.6)	0.180
2007–2011	49 (12.1)	86 (11.9)	135 (12.0)	0.927
2012–2016	43 (6.5)	53 (6.9)	96 (6.8)	0.764
Total length of hospital stay, mean days (95% CI)[a]	16.0 (14.8–17.2)	17.3 (16.4–18.2)	16.8 (16.1–17.5)	0.086
Time to procedure, mean days (95% CI)[a]	3.4 (2.7–4.1)	3.4 (3.0–3.9)	3.4 (3.1–3.8)	0.908
Postoperative length of stay, mean days (95% CI)[a]	13.5 (12.4–14.6)	14.1 (13.2–15.1)	13.9 (13.1–14.6)	0.404
Stoma, *n* (%):[c]				0.001
No	100 (21.0)	118 (13.9)	218 (16.5)	
Yes	376 (79.0)	731 (86.1)	1107 (83.5)	
Anastomosis, *n* (%):[c]				0.004
No	371 (77.9)	715 (84.2)	1086 (82.0)	
Yes	105 (22.1)	134 (15.8)	239 (18.0)	

Percentages and proportions were derived by excluding missing data from the variable. Chi square test for difference. CI, confidence interval.
[a] Analysis of variance.
[b] Values calculated from patients who underwent an open resection or laparoscopic resection; patients who underwent another management approach excluded.

also less likely to have a stoma ($P = 0.005$). However, this is potentially reflective of a favourable patient group, with these patients being younger ($P < 0.001$) with fewer comorbidities ($P = 0.003$) and there being a larger proportion of patients in the lowest clinical risk group (washout 5.5% and resection 8.8%).

In patients who underwent an open operation or laparoscopic resection, we did not identify a trend in stoma ($P = 0.486$) or anastomosis ($P = 0.051$) rates. This is probably due to a combination of factors. The safety of primary anastomosis in generalised peritonitis is still under debate,[12–14] and less severe cases, which were previously anastomosed, are now being managed conservatively.

Our findings identified that cases of perforated diverticulitis managed by a colorectal subspecialist had significantly lower 30-day mortality than patients under the care of other general subspecialists (9.9% vs 12.4%, $P = 0.027$). This remained true following adjustment for other covariates with multivariate regression, thus suggesting colorectal subspecialist care to be an independent predictor of survival. Patients under the care of colorectal surgeons were also found to be less likely to have a stoma formed ($P = 0.001$) with increased rates of primary anastomosis ($P = 0.004$). These findings are comparable with those of Boyce *et al*, who evaluated patient outcomes before and after centralisation of a subspecialist colorectal surgery unit.[17] The group identified a significant reduction in operative mortality with increased anastomosis rate and reduced stoma rate.[17] Biondo *et al* also described similar findings across all emergency colorectal resection.[16] A smaller multicentre study also found that colorectal subspecialists were more likely to form a primary anastomosis. Following multivariate analysis, however, surgical specialty was found not to be an independent risk factor for 30-day postoperative mortality, postoperative surgical or medical adverse events.[21] We would postulate that the experience gained by colorectal subspecialists through their elective work is probably driving the improved outcomes in these higher-risk emergency patients. Many non-colorectal subspecialists may lack in confidence and practice with formation of primary anastomosis, especially in more complex cases of perforation. This difference may also relate to experience with postoperative care, enhanced recovery protocols and other interventions that can impact on a patient's outcome.

The hospital episode statistics data used in this work rely on accurate clinical coding, which is in turn dependent on good documentation from medical staff. In large datasets such as this, small individual inaccuracies in coding are likely to be insignificant and not influential towards overall findings. Admissions are coded by consultant episode of care, rather than operative consultant, thus limiting the conclusions that can be drawn on consultants' operative influence. In a small number of cases, a separate consultant may have operated on the patient during their admission. We would suggest, however, that any possible bias this would introduce would merely dull any observed effect. More complex patients are more likely to be referred to their parent specialty (i.e. colorectal) rather than vice versa. The handover of patients between on-call teams due to time pressure is likely to be negligible and consistent through the study period. The availability of computed tomography reports defining exact Hinchey grade would have contributed to this study, however the use of hospital episode statistics data prohibits classifying the extent of the perforated diverticulitis. We have attempted to partially account for the likely rise in less severe cases of perforated diverticulitis in our analyses through the use of clinical and operative risk grouping. These potential confounders were also included in our multivariate regression analysis.

Conclusions

This study has demonstrated considerable changes and improvements in the management of perforated diverticulitis. Patients are almost half as likely to die from perforated diverticulitis than 15 years ago. We have highlighted the positive impact subspecialisation can have on patient outcomes. Patients under the care of a colorectal surgeon were found to be less likely to have a stoma, more likely to have an anastomosis and more likely to survive. We postulate that continued subspecialisation in the emergency setting will further improve outcomes.

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