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 Påhlman 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 ovarial 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

Information & Registration

www.colorectalsurgery.eu

Systematic review

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Complex abdominal wall reconstruction in the setting of active infection and contamination: a systematic review of hernia and fistula recurrence rates

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Abstract

Aim Minimal evidence exists to guide surgeons on the risk of complications when performing abdominal wall reconstruction (AWR) in the presence of active infection, contamination or enterocutaneous fistula. This study aims to establish the outcomes of contaminated complex AWR.

Method Analysis was conducted according to PRISMA guidelines. Systematic search of the MEDLINE, EMBASE and Pubmed databases was performed. Studies reporting exclusively on single-staged repair of contaminated complex AWR were included. Pooled data were analysed to establish rates of complications.

Results Sixteen studies were included, consisting of 601 contaminated complex AWRs, of which 233 included concurrent enterocutaneous fistula repair. The average follow-up period was 26.7 months. There were 146 (24.3%) reported hernia recurrences. When stratified by repair method, suture repair alone had the lowest rate of recurrence (14.2%), followed by nonabsorbable synthetic mesh reinforcement (21.2%), biological mesh (25.8%) and absorbable synthetic mesh (53.1%). Hernia recurrence was higher when fascial closure was not achieved. Of the 233 enterocutaneous fistula repairs, fistula recurrence was seen in 24 patients (10.3%). Suture repair alone had the lowest rate of recurrence (1.6%), followed by nonbiological mesh (10.3%) and biological mesh reinforcement (12%). Forty-six per cent of patients were reported as having a wound-related complication and the mortality rate was 2.5%.

Conclusion It is feasible to perform simultaneous enterocutaneous fistula repair and AWR as rates of recurrent fistula are comparable with series describing enterocutaneous fistula repair alone. Hernias recurred in nearly a quarter of cases. This analysis is limited by a lack of comparative data and variability of outcome reporting.

Keywords Abdominal wall reconstruction, contamination, complex ventral hernia, enterocutaneous fistula

Introduction

Complex abdominal wall reconstruction (AWR) has developed rapidly over the last 20 years, facilitated by advances in surgical techniques and bioprosthetics. The technique of component separation, to help achieve fascial closure, was first described in 1990 by Ramirez *et al.* [1]. Various modifications to obtain similar tissue mobilization with lower morbidity, including perforator sparing and laparoscopic techniques, have been described [2,3]. More recently the development of biological prosthetics has heralded a new era of innovation.

Despite these advances, complex AWR is still associated with high postoperative morbidity [4]. Multiple preoperative patient factors influence this, including age, comorbidity, smoking and raised body mass index (BMI). Intra-operatively the abdomen often presents a unique challenge as a result of multiple previous laparotomies, previous peritonitis, enterocutaneous fistula (ECF), stomas and, in some cases, prosthetic mesh from a previous hernia repair.

It is recognized that the presence of active infection, contamination and ECF can increase the risk of hernia recurrence, fistula developing and postoperative wound infection. Recently, the Ventral Hernia Working Group (VHWG) developed a grading system to stratify the risk of patients undergoing complex AWR [4]. They grade

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This is the first paper to describe standardized rates of hernia and fistula recurrence in contaminated abdominal wall reconstruction and thereby provides useful guidance to the surgeon for preoperative counselling. It highlights the areas for development of future research in this field.

cases from 1 (clean defects in healthy patients) to 4 (contaminated defects in multi-morbid patients) in order to help advise surgeons of the best repair technique and potential risk of surgery. The utility of this grading system in the prediction of complications in more complex cases, grades 3 and 4, remains contentious. There is no clear advice on long-term outcomes in these patients. It has been suggested that combining these grades and stratifying contamination according to the Centers for Disease Control classification of wound contamination scale improves the accuracy of prediction of wound morbidity [5]. However, others have supported the use of separate grades in cases of severe contamination [6].

While it is well established that the use of mesh reinforcement in hernia surgery greatly reduces the risk of recurrence [7], the role of mesh in complex AWR, particularly in the setting of contamination or ECF, is not clear [4]. It is generally accepted that synthetic nonabsorbable meshes should not be used due to the risk of mesh infection, erosion and fistulization, but synthetic absorbable and biological mesh maybe suitable in selected patients [4]. The advent of biological mesh was hoped to provide the solution to this, and early results demonstrated satisfactory outcomes in contaminated settings [8,9]. Some issues have arisen around the use of crosslinked meshes and the risk of fistula recurrence [10] and the lack of data on long-term outcomes [6]. The variety of products available and a lack of randomized trials add to the confusion.

There are very few studies exclusively investigating contaminated complex AWR. This is probably a reflection of small patient numbers and lack of consensus in practice patterns amongst surgeons in this field. Data on outcomes of contaminated AWR (VHWG grades 3 and 4) tend to be reported as part of work with larger cohorts of patients with all grades of abdominal wall hernia. There has therefore been minimal evaluation on this isolated group of complex patients. However, it is thought that rates of hernia recurrence are higher than in those with clean wounds. It is not known if there is a greater chance of developing a recurrent fistula after ECF repair in the presence of concurrent AWR.

The aim of this study is to evaluate the current literature on contaminated complex AWR and establish the accepted rates of hernia and fistula recurrence.

Method

Search strategy

The study was conducted according to the PRISMA guidelines [11]. A MEDLINE, EMBASE and Pubmed search was carried out to identify all papers reporting on outcomes of contaminated complex AWR. The reference lists of all related studies were reviewed and relevant papers were included.

Search terms

The following Medical Search Headings were used in combination with the functions 'AND' and 'OR': (1) 'enterocutaneous fistula' AND 'hernia' OR 'reconstruction'; (2) 'abdominal wall hernia' AND 'fistula' OR 'infection' OR 'contamination'; (3) 'abdominal wall defect' AND 'fistula' OR 'infection' OR 'contamination'; (4) 'abdominal wall reconstruction' AND 'fistula' OR 'infection' OR 'contamination'.

Inclusion criteria

Studies reporting exclusively on outcomes from single-staged contaminated complex AWR (VHWG grades 3 or 4) from any time period were included. Outcomes of any reconstructive method including the use of prosthetic repairs, component separation with or without mesh placement, repair/resection of ECF and pedicled or free flaps. Only studies published in English were included.

Exclusion criteria

Studies that included outcomes from noncontaminated/clean cases (VHWG grades 1 or 2) or from noncomplex (e.g. primary umbilical or inguinal) hernia repairs were excluded. Studies were excluded if they described management of acute contaminated abdominal defects (e.g. trauma laparotomy) or if they dealt with the defect in a multi-staged approach. Outcomes of paediatric cohorts and case series reporting five or fewer cases were excluded. Review articles, conference abstracts, discussion and comment articles were excluded. Nonhuman, cadeveric and basic science studies were excluded.

Data collection

The search results were assessed and titles screened by the first reviewer (JDH). Papers were assessed by two independent reviewers (JDH and CAL) according to the inclusion and exclusion criteria. For papers published prior to the publication of the VHWG system in 2010, the grade was retrospectively applied by the reviewers from the source data. Included papers were assessed using the Methodological Index for Nonrandomized Studies (MINORs) tool [12] and the Down and Blacks checklist for nonrandomized study assessment [13]. Data

were extracted by the first reviewer and cross-checked independently by the second reviewer. Agreement on included papers and extracted data was reached following discussion between reviewers.

Data extraction

Data were extracted for study demographics (population, study year, study design, sample size), patient demographics (gender, age, BMI, diabetes, smoking status), hernia details (contamination, presence of ECF, VHWG grade), operative details (suture repair, mesh repair/type of mesh, fascial closure achieved, use of component separation), postoperative complications (recurrence of hernia, recurrence of fistula, wound related morbidity, mortality) and average follow-up. Data from the included studies were stored in an Excel spreadsheet (Microsoft, Redmond, Washington, USA). Fisher's exact test was used to test for statistical significance between groups.

Results

A database search identified 1631 studies. This was reduced to 1397 after removal of duplicates. A total of 1223 studies were excluded following title review, and a further 160 were removed following assessment of abstracts and papers according to the inclusion criteria. This resulted in the inclusion of 14 studies [14–27]. Review of reference lists of the screened studies identified a further two articles which met the inclusion criteria [10,28]. Therefore a total 16 studies were assessed for quality and included in the analysis (Fig. 1, Table 1). The MINORs tool revealed a range of scores from 8 to 11 out of a total of 16. Down and Blacks analysis demonstrated scores from 14 to 19 out of a possible total score of 32.

There was one prospective, multicentre, observational outcomes study [28] and one single-centre study of a similar design [24]. Five studies were on prospectively collected databases [10,15,18,19,25]. The remaining studies were retrospective [14,16,17,20–23,26,27]. The time period covered in all studies ranged from 1987 to 2013. A total of 601 patients were included, with an average follow-up of 26.7 months. Follow-up was performed by clinical assessment in five studies [17,22–24,28], a combination of clinical assessment and telephone interviews in three studies [15,18,20] and was not defined in seven studies [10,14,16,19,21,25–27]. None of the studies gave a

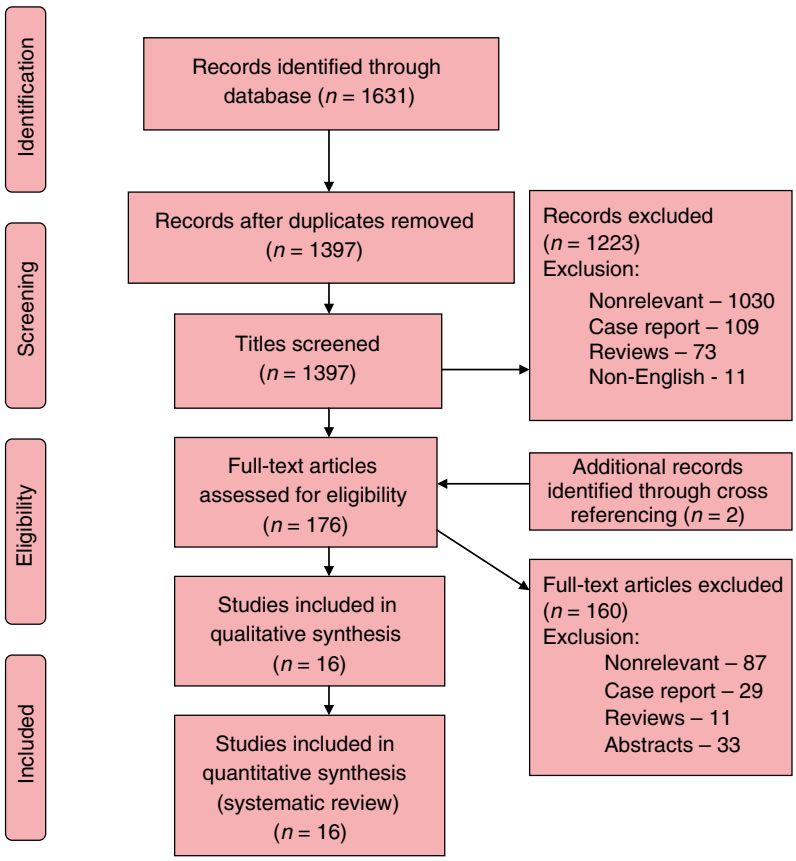

Figure 1 PRISMA flow diagram demonstrating study selection.

Table 1 Summary of study details grouped by study design, including year of publication, years of data collection, total patient numbers and study quality assessment.

Paper	Title	Author	Year of publication	Study type	No. of patients	Year	MINORs*	Down and Blacks†
1	Outcomes in porcine acellular dermal matrix reinforcement of infected abdominal wall defects	Zerbib *et al.*	2012	Prospective enrolled outcomes study, single centre	14	2010–2012	10	15
2	Prospective study of single-stage repair of contaminated hernias using a biological porcine tissue matrix: the RICH Study	Itani *et al.*, RICH study group	2012	Prospective enrolled outcomes study, multi-centre	80	2008–2012	11	18
3	Outcomes analysis of biological mesh use for abdominal wall reconstruction in clean-contaminated and contaminated ventral hernia repair	Sbitany *et al.*	2015	Prospective database, cohort, single centre	41	2009–2013	10	18
4	A retrospective review and observations over a 16-year clinical experience on the surgical treatment of chronic mesh infection. What about replacing a synthetic mesh on the infected surgical field?	Birolini *et al.*	2015	Prospective database, cohort, single centre	41	1996–2012	11	15
5	A 5-year clinical experience with single-staged repairs of infected and contaminated abdominal wall defects utilizing biological mesh	Rosen *et al.*	2013	Prospective database, cohort, single centre	128	2005–2012	11	18
6	Outcomes of simultaneous large complex abdominal wall reconstruction and enterocutaneous fistula takedown	Krpata *et al.*	2013	Prospective database, cohort, single centre	37	2005–2012	9	17
7	Outcome of reconstructive surgery for intestinal fistula in the open abdomen	Connolly *et al.*	2008	Prospective database, cohort, single centre	63	1999–2006	10	16
8	Safety and durability of one-stage repair of abdomimal wall defects with enteric fistulas	Slater *et al.*	2015	Retrospective, cohort, single centre	39	2000–2009	11	19
9	Abdominal wall reconstruction with components separation and mesh reinforcement in complex hernia repair	Nockolds *et al.*	2014	Retrospective, cohort, single centre	23	2009–2012	9	15
10	Surgical treatment of complex enterocutaneous fistulas in IBD patients using human acellular dermal matrix	Taner *et al.*	2008	Retrospective, cohort, single centre	11	2005–2007	8	17
11	Single-stage closure of enterocutaneous fistula and stomas in the presence of large abdominal wall defects using components separation technique	Wind *et al.*	2007	Retrospective, cohort, single centre	32	2000–2007	9	17
12	Laparoscopic component separation in the single-stage treatment of infected abdominal wall prosthetic removal	Rosen *et al.*	2007	Retrospective, cohort, single centre	7	2006–2007	9	15

Table 1 (Continued).

Paper	Title	Author	Year of publication	Study type	No. of patients	Year	MINORs*	Down and Blacks†
13	The single-staged approach to the surgical management of abdominal wall hernias in contaminated fields	Aladeen *et al.*	2006	Retrospective, cohort, single centre	19	1999–2006	9	16
14	Surgical treatment of large contaminated abdominal wall defects	van Geffen *et al.*	2005	Retrospective, cohort, single centre	26	1996–2000	9	14
15	Definitive surgical treatment of infected or exposed ventral hernia mesh	Szczerba *et al.*	2003	Retrospective, cohort, single centre	11	NR	10	14
16	Safety and outcome of use of nonabsorbable mesh for repair of fascial defects in the presence of open bowel	Geisler *et al.*	2003	Retrospective, cohort, single centre	29	1987–2001	9	15
					Total 601			

NR, not reported.
*Methodological Index for Nonrandomized Studies (MINORs) tool [12].
†Down and Blacks checklist for nonrandomized study assessment [13].

clear definition of hernia recurrence and only one differentiated between hernia and bulge [17].

Patient demographics, grade of hernia and reason for contamination are reported in Table 2. Specific details of patient comorbidity and demographics were variably reported. Of the sixteen papers included only nine reported patients' BMI [14,15,17–20,23–25], seven included smoking status [15,17–20,25,28], six had information on the size of the hernia defect [15,17,18,20,22,28] and nine on whether the patient had diabetes [15,17–20,24,25,27,28]. Only six studies reported the number of previous laparotomies [10,15,17,18,20,21] and six the number of previous hernia repairs [15,17,18,20,24,28]. As data reporting was not uniform we were unable to compare preoperative demographics with operative factors and outcomes in most cases.

Of the 601 AWRs performed, 146 hernias recurred (24.3%) (Table 3) [10,14–28]. Suture repair alone demonstrated the lowest level of recurrence, 14.2% (16/113). When biological mesh was used to reinforce the hernia repair the recurrence rate was 25.8% (92/357). When dividing the biological mesh by manufacturing method it was found that when noncrosslinked mesh was used hernia recurrence was 25.1% (86/342). Very few crosslinked meshes were used in these studies, and 6 of the 15 developed a recurrent hernia (40.0%). The use of synthetic mesh resulted in a recurrence rate of 53.1% (17/32) when using absorbable mesh and 21.2% (21/99) with nonabsorbable mesh. When comparing the rate of recurrence based on fascial closure, independent of mesh use, hernias recurred significantly less frequently when the fascia was closed compared wuth when a bridging mesh was used [16% (48/300) *vs* 40% (18/45), respectively; $P \leq 0.001$].

Two hundred and thirty-three of the operations included repair of an ECF, of which 24 recurred (10.3%). Three studies reporting 33 ECF repairs, including seven recurrences, did not include enough detail on recurrence based on repair method and were excluded from this analysis [14,22,23]. This resulted in 200 patients in the final pooled analysis (Table 4) [10,15–21,24,27,28]. Recurrence was seen in 17 patients (8.5%). Suture repair alone was associated with the lowest rate of recurrence (1.6%, 1/63). Repairs reinforced with nonbiological mesh were found to have a recurrence rate of 10.3% (3/29) [absorbable mesh 11.8% (2/17); nonabsorbable mesh 8.3% (1/12)]. Biological mesh had the highest recurrence rate at 12.0% (13/108); however, of the 15 crosslinked meshes used five developed a recurrent fistula (33.3%). Use of noncrosslinked biological mesh resulted in a recurrent fistula in 8.6% of cases (8/93).

In some cases it was possible to compare a combination of closure techniques. In Table 5 suture repair alone is compared with component separation and suture and component separation and mesh repair to assess risk of hernia and fistula recurrence.

Table 6 demonstrates the total number of different mesh types used. A total of 131 synthetic meshes were

Table 2 Patient demographics including age, BMI, diabetes and smoking status. Further demographic details were sparsely reported.

Paper*	No. of patients	Gender (male) (%)	Age (years)	Average BMI (kg/m^2)	Diabetes (%)	Smoker (%)	Average follow-up (months)	VHWG Grade 3	VHWG Grade 4	ECF	Bowel resection	Infected mesh	Stoma	Open/ infected wound/sinus
1	14	4 (29)	60	34.1	4 (29)	NR	13	0	14	6	NR	8	NR	NR
2	80	47 (59)	57	NR	17 (21)	14 (18)	24	60	20	7	27	15	31	4
3	41	27 (66)	52.4	38.4	24 (59)	6 (15)	25	36	5	3	13	3	20	NR
4	41	18 (43.9)	53.4	31.2	10 (24.4)	16 (39)	74	0	41	0	NR	41	NR	NR
5	128	52 (41)	58.2	34.1	65 (51)	29 (23)	21.7	46	82	25	17	45	24	12
6	37	17 (46)	59	31.3	21 (57)	8 (22)	20	0	37	37	37	10	NR	NR
7	63	31 (49)	50	NR	NR	NR	29	0†	63†	63	63	NR	NR	NR
8	39	27 (69)	61.2	24.4	8 (21)	9 (23)	62.7	0	39	39	39	NR	NR	NR
9	23	15 (65)	57	NR	NR	NR	17	13	10	8	NR	NR	15	NR
10	11	5 (45)	46	NR	NR	NR	12	0†	11†	11	11	NR	NR	NR
11	32	22 (69)	43	21.7	NR	NR	20	0†	32†	15	9	0	21	24
12	7	4 (57)	54	37	3 (43)	1 (14)	4.5	0†	7†	0	NR	7	0	6
13	19	19 (100)	61	34.3	NR	NR	14	0†	19†	7	8	14	NR	3
14	26	15 (58)	49	NR	NR	NR	27	14†	12†	9	13	NR	12	4
15	11	5 (45)	54.5	NR	4 (36.4)	NR	24	0†	11†	3	4	11	NR	NR
16	29	11 (37.9)	67	NR	NR	NR	39	29†	0†	0	4	0	26	0
	601	319 (53.1)			156/398 (39.2)	83/373 (22.3)	26.7	198	403	233				

NR, not reported; ECF, enterocutaneous fistula; VHWG, Ventral Hernia Working Group.

*Paper number refers to numbers allocated in Table 1.

†Retrospectively applied grading for paper published prior to 2010.

Table 3 Hernia recurrence rates stratified by repair method.

	Suture repair		Biological mesh		Synthetic mesh	
Paper	Recurrence	Total	Recurrence	Total	Recurrence	Total
Zerbib *et al.* [24]	0	0	6	14	0	0
Itani *et al.*, RICH study group [28]	0	0	22	80	0	0
Sbitany *et al.* [19]	0	0	5	41	0	0
Birolini *et al.* [25]	0	0	0	0	3	41
Rosen *et al.* [18]	0	0	40	128	0	0
Krpata *et al.* [15]	0	1	12	36	0	0
Connolly *et al.* [10]	0	34	5	12	13	17
Slater *et al.* [20]	10	26	0	0	2	13
Nockolds *et al.* [16]	0	0	2	17	1	6
Taner *et al.* [21]	0	0	0	11	0	0
Wind *et al.* [23]	3	14	0	0	4	18
Rosen *et al.* [17]	0	0	0	7	0	0
Aladeen *et al.* [14]	0	5	0	11	2	3
van Geffen *et al.* [22]	2	22	0	0	0	4
Szczerba *et al.* [27]	1	11	0	0	0	0
Giesler *et al.* [26]	0	0	0	0	13	29
Total	16	113	92	357	38	131
Percentage	14.2		25.8		29.0	

Table 4 Fistula recurrence rates stratified by repair method.

	Suture repair		Biological mesh		Synthetic mesh	
Paper	Recurrence	Total	Recurrence	Total	Recurrence	Total
Zerbib *et al.* [24]	0	0	0	6	0	0
Itani *et al.*, RICH study group [28]	0	0	1	7	0	0
Sbitany *et al.* [19]	0	0	0	3	0	0
Birolini *et al.* [25]	0	0	0	0	0	0
Rosen *et al.* [18]	0	0	2	25	0	0
Krpata *et al.* [15]	0	0	5	36	0	0
Connolly *et al.* [10]	0	34	5	12	2	17
Slater *et al.* [20]	1	26	0	0	1	12
Nockolds *et al.* [16]	0	0	0	8	0	0
Taner *et al.* [21]	0	0	0	11	0	0
Wind *et al.* [23]	NR	NR	NR	NR	NR	NR
Rosen *et al.* [17]	0	0	0	0	0	0
Aladeen *et al.* [14]	NR	NR	NR	NR	NR	NR
van Geffen *et al.* [22]	NR	NR	NR	NR	NR	NR
Szczerba *et al.* [27]	0	3	0	0	0	0
Giesler *et al.* [26]	0	0	0	0	0	0
Total	1	63	13	108	3	29
Percentage	1.6		12.0		10.3	

NR, not reported.

used: 99 nonabsorbable and 32 absorbable. The most prevalent biological mesh used in these studies was Strattice™ (264) (Lifecell Corporation, New Jersey, USA). Of the remainder, 76 were noncrosslinked [Alloderm© (Lifecell Corporation), Biodesign© (Cook Medical, Bloomington, Indiana, USA), Xenmatrix™ (Bard Davol, Warwick, Rhode Island, USA)], 15 had additional crosslinking [Permacol™ (Covidien

Table 5 The breakdown of hernia [10,14,16,17,21–24,26–28] and fistula [10,14,19,21,22,24,27] recurrence according to the use of component separation technique.

	Recurrence with C/S	Number	Percentage
Fistula recurrence	Suture repair alone	0/32	0
	C/S and suture repair	3/32	9.4
	C/S and biological mesh	5/69	7.2
	C/S and synthetic mesh	2/16	12.5
Hernia recurrence	Suture repair alone	0/32	0
	C/S and suture repair	6/72	8.3
	C/S and biological mesh	28/145	19.3
	C/S and synthetic mesh	13/39	33.3

C/S, component separation.

Table 6 The total number of each type of mesh used.

Mesh type	Mesh	N. used
Synthetic	Polypropylene	82
	Polyglactin	32
	Polyester	8
	Vypro	3
	Ultrapro	3
	Proceed	3
Biological	Strattice	264
	Alloderm	53
	Biodesign	18
	Permacol	15
	XenMatrix	5
	BioA	4

Medtronic, Minneapolis, Minnesota, USA)] and four were a biosynthetic mesh [Bio A© (Gore Medical, Flagstaff, Arizona, USA)].

Short-term postoperative complication rates in all studies were variably reported (Table 7). Two papers used the standardized Clavien–Dindo scale of reporting complications [20,24]. Eight papers reported total numbers of patients who had complications [10,14,17,20–23,25]. Only one paper [15] used a standardized method of reporting wound infection, therefore no further analysis was possible. Six papers reported data on medical complications postoperatively [17,20–23]; 46.1% (277/601) of patients were reported as having a wound-related complication and 15 deaths were reported (2.5%) (Table 8).

Discussion

This review aimed to evaluate the rates of hernia and fistula recurrence following contaminated complex AWR. No previous systematic review has focused on outcomes of contaminated AWR. Across all VHWG grades systematic review data reveal a hernia recurrence rate of 15.2% with an average follow-up of 13.6 months [29]. A separate review focusing on biological mesh repair found a hernia recurrence rate of 20% over a similar follow-up period [30]. The current literature review suggests that in the contaminated setting biological mesh repairs have a similar recurrence rate over an average follow-up of 2 years. No long-term follow-up data exist for patients undergoing contaminated AWR with suture repair alone. There are no controlled trials of suture repair *vs* mesh repair or trials comparing different meshes, therefore these groups are not directly comparable. The heterogeneity inherent in this patient group is demonstrated by the lack of consistent reporting of patient comorbidity and previous laparotomy/hernia repair. The lower rate of hernia recurrence observed in the suture repair group is not consistent with existing literature that mesh repair is superior to suture alone. It is difficult to ascertain the reason for this; however, it is possible the smaller less complex hernias were repaired without a mesh and therefore a lower recurrence rate would be expected. Any suggestion that mesh repair increases the recurrence rate in the contaminated field would not be supported by other data in the literature. It is likely that biological meshes were used in the more complex cases, but these details are not reported and therefore it is impossible to directly compare mesh *vs* suture reconstruction.

Opinion is divided on how best to manage large ventral hernias with coexisting ECF. This review focuses on single-staged repair; however, some surgeons advocate multi-staged surgical management consisting of initial surgical closure/treatment of the fistula and wound closure with a bridging mesh or simple skin grafting followed by definitive AWR at a later date [31–34]. The advantages of this technique are thought to include a

Table 7 Consistency of reporting complication data across all papers.

Author	All	Wound related	Standardized wound infection	Mesh related	Medical complications	Clavien–Dindo*	Mortality
Zerbib *et al.* [24]		●		●		●	●
Itani *et al.*, RICH study group [28]		●		●			●
Sbitany *et al.* [19]		●		●			●
Birolini *et al.* [25]	●	●		●			●
Rosen *et al.* [18]		●					●
Krpata *et al.* [15]		●	●		●		●
Connolly *et al.* [10]	●	●		●	●		●
Slater *et al.* [20]	●	●		●	●	●	●
Nockolds *et al.* [16]		●		●			●
Taner *et al.* [21]	●	●			●		●
Wind *et al.* [23]	●	●		●	●		●
Rosen *et al.* [17]	●	●			●		●
Aladeen *et al.* [14]	●	●		●	●		●
van Geffen *et al.* [22]	●	●			●		●
Szczerba *et al.* [27]		●					●
Giesler *et al.* [26]		●					●
Total	8	16	1	9	8	2	16

*Clavien–Dindo first validated in 2004.

Table 8 Short-term postoperative complication rates.

Author	All	Wound related	Medical complications	Mortality
Zerbib *et al.* [24]	NR	8	NR	0
Itani *et al.*, RICH study group [28]	NR	53	NR	5
Sbitany *et al.* [19]	NR	22	NR	0
Birolini *et al.* [25]	NR	61	NR	3
Rosen *et al.* [18]	NR	24	NR	1
Krpata *et al.* [15]	52	23	NR	3
Connolly *et al.* [10]	28	18	23	1
Slater *et al.* [20]	14	16	NR	0
Nockolds *et al.* [16]	NR	13	NR	0
Taner *et al.* [21]	5	5	0	0
Wind *et al.* [23]	22	9	10	0
Rosen *et al.* [17]	3	2	1	0
Aladeen *et al.* [14]	9	7	5	1
van Geffen *et al.* [22]	17	8	5	1
Szczerba *et al.* [27]	NR	2	NR	0
Giesler *et al.* [26]	NR	6	NR	0
Total		277		15

NR, not reported.

reduction in operative time and in medical and wound morbidity. Conversely this approach exposes the patient to a second, or even a third, operation, increasing the hospitalization cost and anaesthetic risk. Additionally, there is a risk of recurrent or *de novo* fistula formation [33,34].

This study shows that the rates of recurrent ECF following single-staged repair with AWR and cohorts of isolated ECF repair are comparable at approximately 10% [35–37]. Mortality in this cohort is also found to be low (2.5%) and in keeping with reports of ECF repair in isolation [35,36]. Wound morbidity is

expected to be high in a population of patients undergoing surgery in a contaminated or dirty field, and a rate of 46.1% is in keeping with data for surgical site infection in dirty wounds [38]. It can therefore be concluded that concurrent ECF repair and single-staged AWR is a safe method of dealing with both complex surgical problems in a single operation, thus reducing the number of operations, the cost of hospital stay and associated morbidity.

On breaking down the data by use of component separation some studies did not give sufficient detail of the recurrent cases to establish what repair technique had been used. When this was possible, numbers in each category were significantly lower and therefore robust conclusions could not be drawn; however, these data seem to imply that the use of component separation techniques in contaminated AWR does not affect the rates of hernia or fistula recurrence. The low hernia recurrence rate (0%) for suture repair implies that these cases had less complex defects than those requiring component separation and/or mesh repair, therefore it is not prudent to draw any significant conclusions from this figure.

This study may demonstrate the advantage of biological over synthetic mesh in this field, with lower rates of both hernia and fistula recurrence; however, the heterogeneity of the groups makes it difficult to make this comparison. The use of biological mesh in the contaminated field remains contentious. All meshes provoke an inflammatory response when implanted and it is a balance between this reaction and the integration of the mesh that dictates its long-term function [39]. The presence of inflammatory cells in the infected wound may provoke a larger than normal response to the mesh, resulting in mesh degradation. Some meshes undergo a process of additional crosslinking in order to strengthen the prosthetic against enzymatic degradation. The only additionally crosslinked mesh used in the included studies was Permacol. Early data suggested a high rate of recurrent fistula when using crosslinked meshes [10], and this could explain why so few were used in these studies. Some studies have suggested that the additional crosslinking can modulate the inflammatory response and improve mesh integration and tissue quality over time and reduce recurrence rates when compared with noncrosslinked mesh [39]. However, further data comparing different biological meshes found that meshes with additional crosslinking resulted in higher rates of infection and explanting [40]. The recently published guidelines from the European Society of Coloproctology [41] on surgery in patients with intestinal failure recommend the use of noncrosslinked mesh in AWR in patients with concurrent ECF repair. These data suggest that noncrosslinked mesh is comparatively safe to use in the presence of ECF, but hernia recurrence is still high.

The drawbacks of this review are clear and are a recurring problem with data in this field. There are no prospective controlled trials in the repair of ECF and AWR. No comparative studies have thus far been conducted, and the bulk of data presented here come from small retrospective cohorts. This is a reflection of the paucity of cases in this specialist field and the fact that patients have unique considerations that make it impossible to design robust trials. The retrospective application of the VHWG grade to papers published prior to 2010 limits the accuracy of these included patients, as reviewers did not have access to the patients' original clinical notes. Every care has been taken to accurately apply the grade as all included studies had explicit descriptions of the source of contamination detailed in the body of the paper. More concerning than these factors is the lack of consistent data reporting. Assessment of quality of the studies included in the analysis revealed that there were no ideal studies; however, scores were consistent across the studies. Researchers should aim to maximize the effectiveness of the data available by keeping prospective databases, performing collaborative studies and reporting key outcomes measures. These should include patient demographic data on factors that are known to affect hernia recurrence and wound infection rates, such as smoking status and BMI. Likewise, few studies used a standardized measure for reporting complications. One study used the Centers for Disease Control wound infection scale, but other definitions and methods of assessing wound complications exist. The validated Clavien–Dindo classification of surgical complications was only used in two studies. These data highlight the lack of consensus amongst surgical researchers as to how to report and grade complications, which contributes to the difficulty in comparing studies.

This study demonstrates the feasibility of single-staged ECF repair and complex AWR. Fistula recurrence rates are comparable with reported series of fistula repair alone. Noncrosslinked biological mesh would appear to be safer to use than crosslinked mesh with regard to fistula recurrence.

Hernia recurrence rates remain high in the contaminated setting, even when biological mesh is used to reinforce the repair. While it is not possible to directly compare suture and mesh repair in these studies, due to significant between-group heterogeneity, this analysis would suggest a controlled trial of suture *vs* mesh repair in this group is warranted. There should be standardization of reporting of

patient demographics, wound and patient complications in future studies in this field.

Author contributions

JDH helped design the study, acquired and interpreted the data and drafted and approved the final manuscript; YM helped design the study, interpreted the data and drafted and approved the final manuscript; CAL helped acquire and interpret the data and drafted and approved the final manuscript; JW contributed to the study design and concept, revised the critically important intellectual content and approved the final manuscript; CJV contributed to the study design and concept, revised the critically important intellectual content and approved the final manuscript.

Conflicts of interest

JH: course funding from Acelity; nil related to current review. YM: honorarium as speaker for Medtronic and Astellas; research grant from Medtronic; nil related to current review. CAL: nil related to current review. JW: nil related to current review. CJV: consultant on advisory board for Acelity.

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