Abdominal Wall Closure

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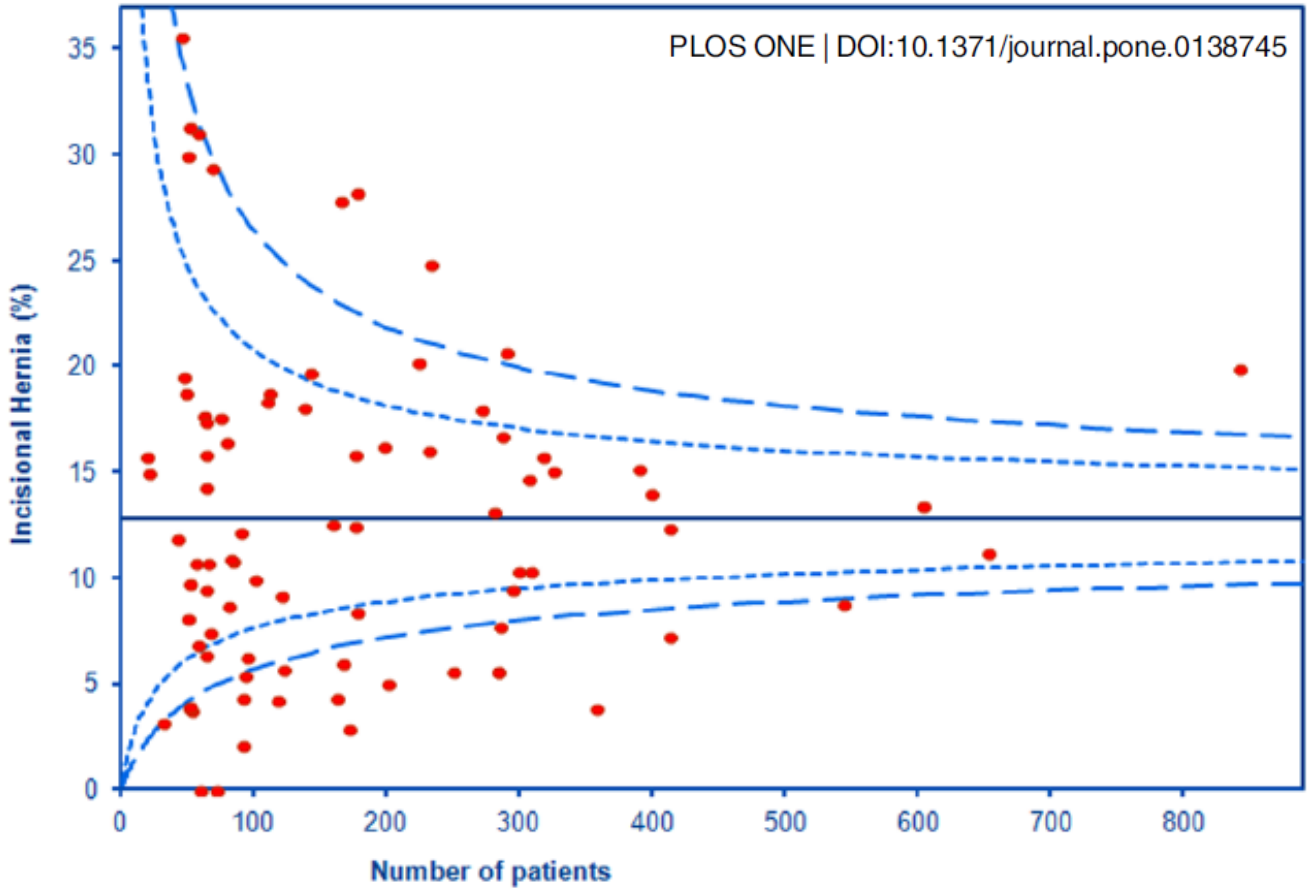
Incisional hernias are common

- Rate depends upon follow up:
  - Clinical vs CT follow up
  - Symptomatic vs asymptomatic
  - Duration
- Wide variation reported
  - Emergency > elective
  - Contaminated > clean
  - Technical factors
  - Patient factors



Colorectal surgery is a common cause

Incisional hernia after surgery for colorectal cancer: a population-based register study

Harald Söderbäck[1,2] · Ulf Gunnarsson[3] · Per Hellman[4] · Gabriel Sandblom[5,6]

International Journal of Colorectal Disease (2018) 33:1411–1417

- Sweden CRC registry ~ 29000 cases
  - Men > women
  - >70years
  - Prolonged surgery
  - BMI > 30
  - Wound complications

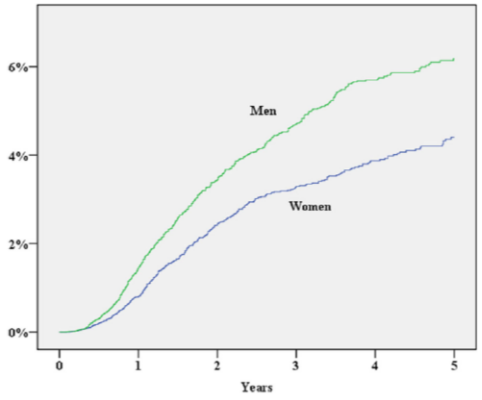


Fig. 2 Gender vs cumulative incidence of incisional hernia

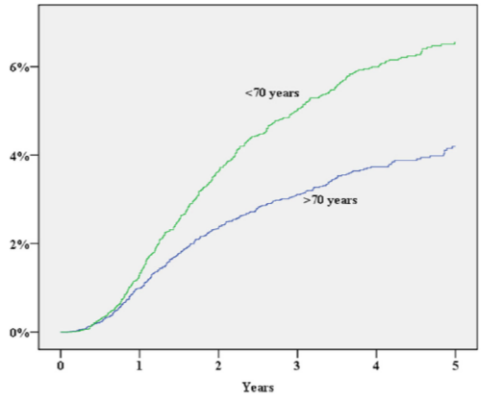


Fig. 3 Age vs cumulative incidence of incisional hernia

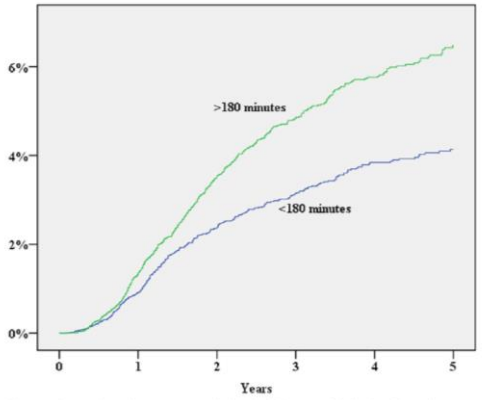


Fig. 4 Operation time vs cumulative incidence of incisional hernia

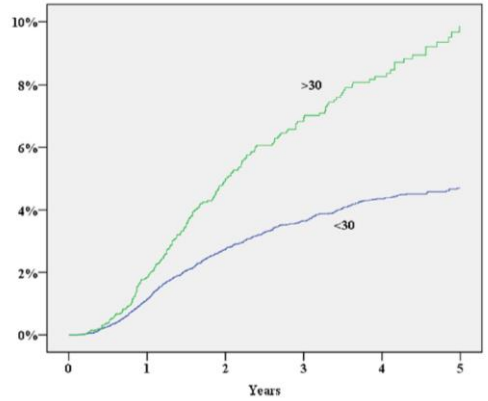


Fig. 5 BMI vs cumulative incidence of incisional hernia

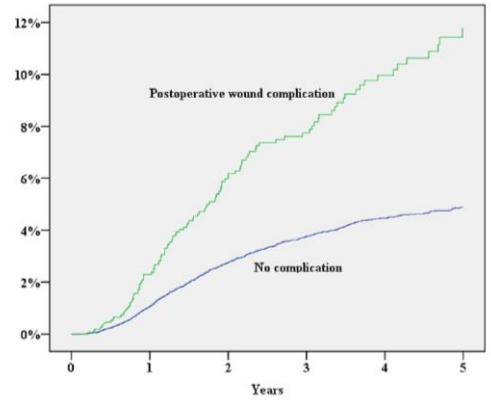


Fig. 6 Wound complication vs cumulative incidence of incisional hernia

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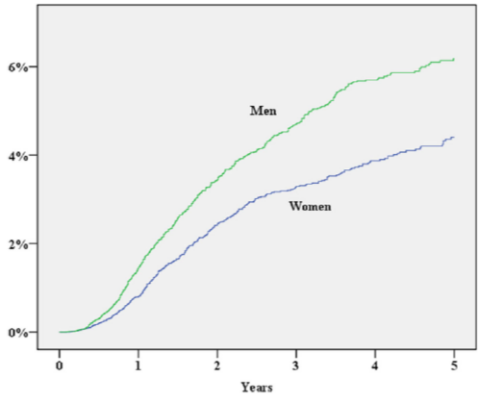

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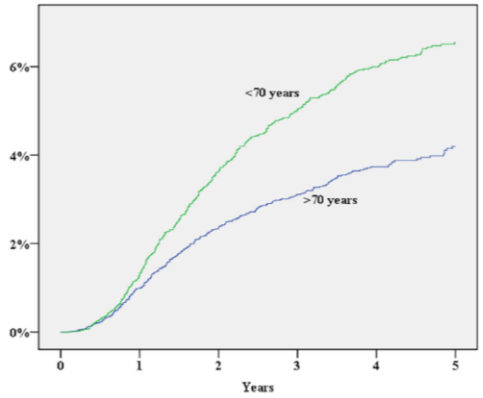

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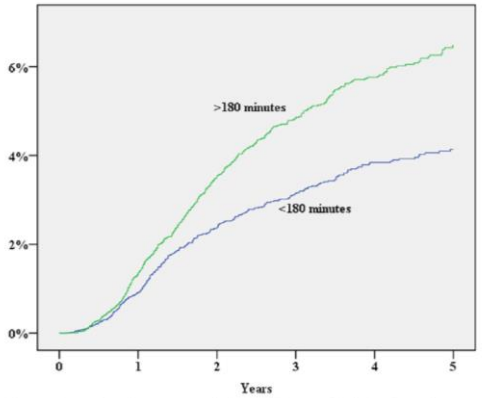

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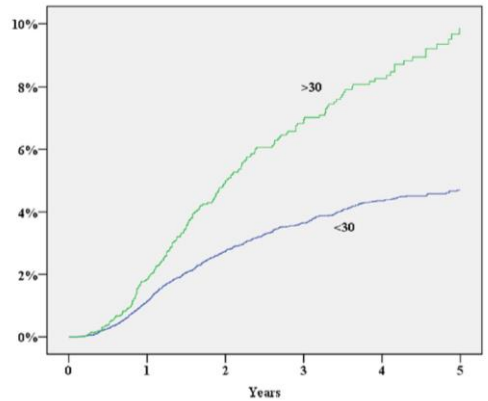

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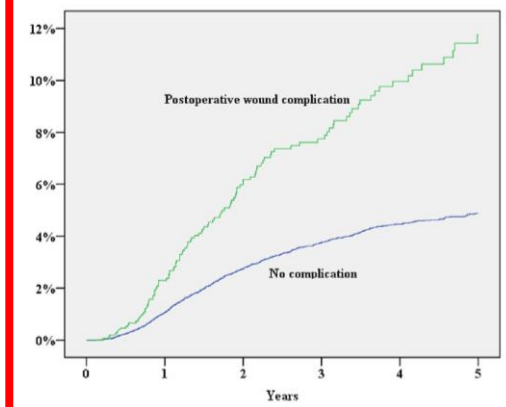


Fig. 6 Wound complication vs cumulative incidence of incisional hernia

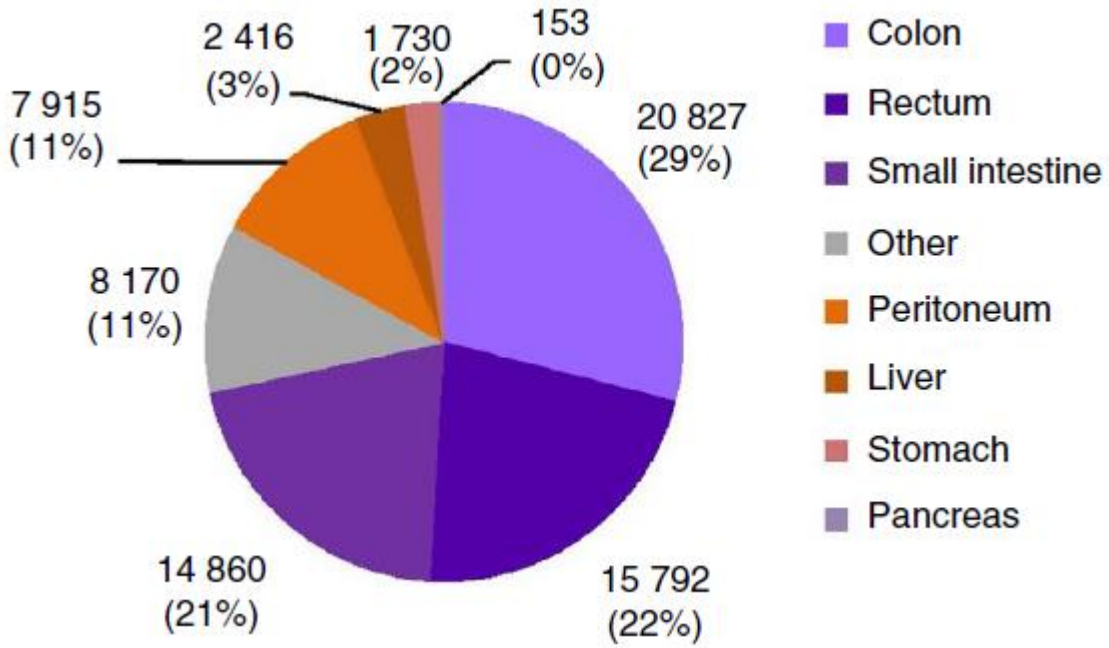
Colorectal surgery is a common cause

ORIGINAL ARTICLE

Incidence and risk factors for incisional hernia and recurrence: Retrospective analysis of the French national database

Benoit Gignoux[1] | Yves Bayon[2] | Damien Martin[3] | Raksmey Phan[4] | Vincent Augusto[4] | Benjamin Darnis[1] | Marianne Sarazin[4]

Colorectal Disease. 2021;23:1515–1523.

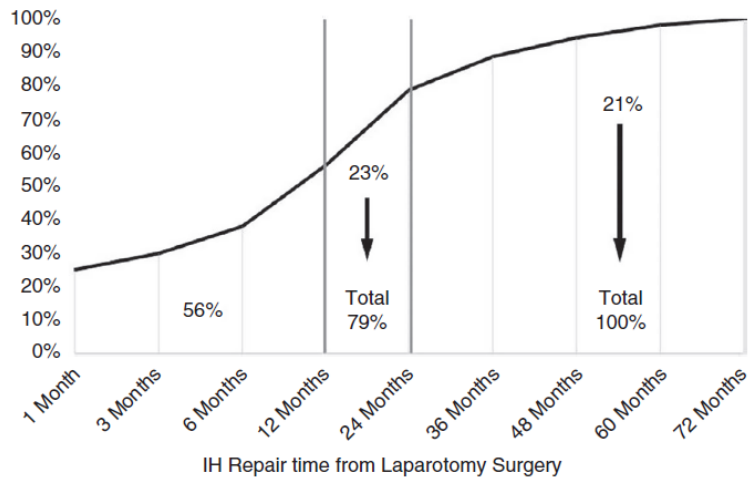


- France - IHR 17% @ 5 years

  Laparotomy for digestive surgery

  72% small bowel / colon / rectum

  ~ 80% repaired < 2years



Stop incisional hernia denial

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COMMENTARY

It is time for colorectal surgeons to stop incisional hernia denial

Jared Torkington

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June's edition of *Colorectal Disease* sees the publication of a paper by Gignoux and colleagues that could be recommended to all colorectal surgeons to read and reflect upon [1]. It is a retrospective analysis of the French nationwide hospital database, the Programme de Medicalisation des Systemes d'Informations (PMSI). The authors have considered the incidence and risk factors for incisional hernia in over 400,000 laparotomies and the recurrence rate after subsequent repair.

The question many will be asking at this point is 'Why is this being published in a colorectal journal?' Indeed, in many healthcare systems, hernia surgery is rapidly developing as a subspeciality of general surgery, so incisional hernia repair will fall less and less to the colorectal surgeon in the future. This specialization will undoubtably reduce failure rates after primary repair of incisional hernia.

Interest in the prevention of incisional hernia has risen slowly in the last few years, perhaps as a result of the advent of the small stitch as a possible solution and the potential use of mesh [2]. However, what, if any, is the role of the colorectal surgeon in the prevention of incisional hernia?

The data that Gignoux et al. present make sobering reading. The headline, according to these French data, is that the risk of requiring incisional hernia repair after any laparotomy is 5%. Clearly, the risk of incisional hernia is much higher; this paper only collects data on those that have been repaired. The actual incidence of incisional hernia after laparotomy is likely to be at least three times as high. Let us put that another way: after any laparotomy 1 in 20 patients will have an operation to fix an incisional hernia (with a variable level of success). How many of us mention that at the time of taking of informed consent? The shock comes when you notice that, of all the patients in a cohort of the highest incidence of repair by procedure, 72% were following lower gastrointestinal surgery – over to us, the colorectal surgeons.

There are some common myths that need dispelling. The first is that incisional hernia is not a problem in colorectal surgery; these data and others clearly demonstrate that it is [3]. The second is that laparoscopic colorectal surgery prevents incisional hernia; it does not, but transverse incisions do [3,4]. I think this may be the most powerful argument in support of the use of intracorporeal anastomosis in right hemicolectomy to allow a Pfannenstiel extraction site, but I digress. The third is that 4:1 is the magic suture length to wound length ratio (SL:WL). Jenkins' rule, which all surgeons learn for exams, was based on a series to prevent burst abdomen not incisional hernia [5]. In the STITCH study comparing small bites with large bites, there was a significant difference in incisional hernia at 1 year but the large bites (control) group still had a mean SL:WL of 4:1 [6]. The European Hernia Society is currently revising its guidelines on abdominal wall closure, and it will be interesting to see the new recommendation on this ratio; it must surely be higher [4].

Incisional hernia in the 21st century remains a real problem for both patients and healthcare systems. Prevention involves recognizing the importance of a sound evidence-based closure technique, reducing surgical site infection and perhaps, as we learn more, identifying high-risk patients and modifying strategy accordingly. It is time for colorectal surgeons to start owning the problem of incisional hernia in our practice and doing more to prevent it.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analysed in this study.

REFERENCES

1. Gignoux B, Bayon Y, Martin D, Phan R, Augusto V, Darnis B, et al. Incidence and risk factors for incisional hernia and recurrence: retrospective analysis of the French national database. Colorectal Dis. 2021;23:1515–23. https://doi.org/10.1111/codi.15581
2. Harris HW, Hope WH, Adrales G, Andersen DK, Deerenberg EB, Diener H, et al. Contemporary concepts in hernia prevention: Selected proceedings from the 2017 International Symposium on the Prevention of Incisional Hernias. Surgery. 2018;164(2):319–26.
3. Karlsson N, Zackrisson S, Buchwald P. Computed tomography verified prevalence of incisional hernia 1 year postoperatively after colorecta; cancer resection. Scan J Surg. 2020;16. https://doi.org/10.1177/1457496920976053
4. Muysoms FE, Antoniou SA, Bury K, Campanelli G, Conze J, Cuccurullo D, et al. European Hernia Society guidelines on the closure of abdominal wall incisions. Hernia. 2015;19(1):1–24.
5. Jenkins TP. The burst abdominal wound: a mechanical approach. Br J Surg. 1976;63:873–6.
6. Deerenberg EB, Harlaar JJ, Steyerberg EW, Lont HE, van Doorn HC, Heisterkamp J, et al. Small bites versus large bites for closure of abdominal midline incisions (STITCH): a double-blind, multicentre, randomised controlled trial. Lancet. 2015;26:1254–60.

Stop incisional hernia denial

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Closing time is not coffee time

Leading article

Abdominal wall closure

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For decades, opening and closing the abdominal wall has been a rite of passage for surgical training. This task was often left to a more junior member of the surgical team, as reward for assisting with a long laparotomy. Supervision of this task was variable. Yet, closure of the abdominal wall is an important step for the patient; the risk is of incisional hernia, the commonest major complication of a laparotomy, with its attendant symptoms and frequent need for further surgery. Despite this, there is a noticeable lack of research focusing on the optimal method to close the abdominal wall. Indeed, when the first European Hernia Society (EHS) guidelines[1] on the closure of the abdominal wall were published in 2015, one of the few strong recommendations to reduce the risk of incisional hernia formation was to avoid the midline. Yet the midline remains the main technique of access to the abdomen at open surgery, and often for specimen extraction after laparoscopic surgery.

Studies have been done on suture type, absorbable *versus* non-absorbable, rapidly *versus* slowly absorbable, mass *versus* layered closure, continuous *versus* interrupted, and so on. However, many of the prospective trials compared several variables between the study arms, and failed to monitor the technical details of the suturing technique. Indeed, in the 23 RCTs included in the MATCH review[2], there was no evidence when using the same suture or suture technique in both study arms that any suture material was superior to another, or that continuous suture was superior to interrupted suture.

It is well recognized that closure of the abdominal wall can fail, both acutely, as in the so-called burst abdomen, and more chronically, as an incisional hernia. In the acute burst abdomen, technical factors such as failure of the suture knot are well recognized, in addition to the possible effects of abdominal hypertension. When an incisional hernia develops, surgeons are more likely to blame the patient, such as poor collagen, obesity, smoking, steroid use and/or cachexia, and perhaps not reflect on their closure technique.

At the time of publication, the EHS guidelines noted the improved results, in terms of reducing burst abdomen, wound infection rate and lower incisional hernia rate of the small bite, small-stitch closure technique, first reported by Israelsson's group[3]. Still based on the old concept of the 4 : 1 suture to wound length ratio[4], the use of a smaller suture size with small bites of the linea alba was revolutionary, but has not gained rapid acceptance in surgical practice. A second randomized trial from the Netherlands[5] has confirmed some of these findings in terms of fewer incisional hernias, but no significant reduction in wound infection rate or the risk of burst abdomen. But, as in many RCTs, the exclusion criteria make generalization of the study's findings difficult. Both trials excluded emergency surgery, as well as obese patients – the group that perhaps has the highest risk of incisional hernia. A Danish group[6] used the small-stitch, small-bite technique in a large series of emergency midline laparotomies, with a marked reduction in the rate of burst abdomen compared with historical controls. The use of so-called near and far (Hughes) stitches has also been described, but it too has not become common practice. However, the Hughes Abdominal Repair Trial (HART)[7] is busy recruiting from centres throughout the UK, and its results are awaited. Both arms of this trial[7] use continuous large-bite, large-stitch mass closure of the midline, with the study arm also incorporating a series of horizontal and two vertical mattress sutures within a single non-absorbable suture to the linea alba.

The superiority of mesh in incisional hernia repair over suture repair in terms of hernia recurrence is well known. This has led to an active interest in using mesh at the same time as abdominal wall closure, especially in high-risk groups such as those undergoing aortic aneurysm surgery and obese patients, with promising results[8]. To date, however, mesh-augmented closure has been compared with large-stitch, large-bite closure, so it remains to be seen what additional benefit mesh may have in abdominal wall closure over small-stitch, small-bite techniques. In addition, what mesh and where should it be sited are unanswered questions.

Effective healing of the abdominal wall without incisional hernia formation is not just about suture type or suture technique. Particularly when it comes to elective surgery, improving exercise tolerance, treating sarcopenia, weight loss in the obese, stopping smoking, reducing immunosuppression where possible, along with other surgical interventions to minimize wound infection such as appropriate skin decontamination, wound protection, wound lavage and delayed skin closure, all have a role to play. However, which of these and other interventions have the greatest contribution has not been well studied. Although prehabilitation has clear benefits for the patient[9], this has not in itself been shown to affect incisional hernia rates to date.

Meticulous attention to surgical technique remains important, not just when in the abdomen, but also when closing the abdominal wall. Closing time is not coffee time! It is an important part of the operation, and the skin wound is the only bit the patient actually gets to see. Sound closure should be within the skills of any abdominal surgeon, without the need to resort to a closing team, except in rare circumstances. Current evidence points to small-bite, small-stitch as the way ahead. Other novel suture types[10] may change this view in years to come. At least a 4 : 1 stitch to wound ratio seems to be important for both large- and small-stitch/bite closure, so it makes sense to measure this stitch to wound ratio as a routine with every abdominal wall closure, and document it in the operation note. Indeed, in Professor Israelsson's hospital, if the ratio is less than 4 : 1 the only instrument that the scrub nurse is allowed to hand to the surgeon is a pair of scissors, to cut the stitch out and start again.

Disclosure

The author declares no conflict of interest.

References

1 Muysoms FE, Antoniou SA, Bury K, Campanelli G, Conze J, Cuccurullo D *et al.*; European Hernia Society. European Hernia Society guidelines on the closure of abdominal wall incisions. *Hernia* 2015; **19**: 1–24.

2 Henriksen NA, Deerenberg EB, Venclauskas L, Fortelny RH, Miserez M, Muysoms FE. Meta-analysis on materials and techniques for laparotomy closure: the MATCH Review. *World J Surg* 2018; **42**: 1666–1678.

3 Millbourn D, Cengiz Y, Israelsson LA. Effect of stitch length on wound complications after closure of midline incisions: a randomized controlled trial. *Arch Surg* 2009; **144**: 1056–1059.

4 Jenkins TP. The burst abdominal wound: a mechanical approach. *Br J Surg* 1976; **63**: 873–876.

5 Deerenberg EB, Harlaar JJ, Steyerberg EW, Lont HE, van Doorn HC, Heisterkamp J *et al.* Small bites *versus* large bites for closure of abdominal midline incisions (STITCH): a double-blind, multicentre, randomised controlled trial. *Lancet* 2015; **386**: 1254–1260.

6 Tolstrup MB, Watt SK, Gögenur I. Reduced rate of dehiscence after implementation of a standardized fascial closure technique in patients undergoing emergency laparotomy. *Ann Surg* 2017; **265**: 821–826.

7 Cornish J, Harries RL, Bosanquet D, Rees B, Ansell J, Frewer N *et al.*; HART Trial Management Group. Hughes Abdominal Repair Trial (HART) – abdominal wall closure techniques to reduce the incidence of incisional hernias: study protocol for a randomised controlled trial. *Trials* 2016; **17**: 454.

8 Borab ZM, Shakir S, Lanni MA, Tecce MG, MacDonald J, Hope WW *et al.* Does prophylactic mesh placement in elective, midline laparotomy reduce the incidence of incisional hernia? A systematic review and meta-analysis. *Surgery* 2017; **161**: 1149–1163.

9 Howard R, Yin YS, McCandless L, Wang S, Englesbe M, Machado-Aranda D. Taking control of your surgery: impact of a prehabilitation program on major abdominal surgery. *J Am Coll Surg* 2019; **228**: 72–80.

10 Dumanian GA, Tulaimat A, Dumanian ZP. Experimental study of the characteristics of a novel mesh suture. *Br J Surg* 2015; **102**: 1285–1292.

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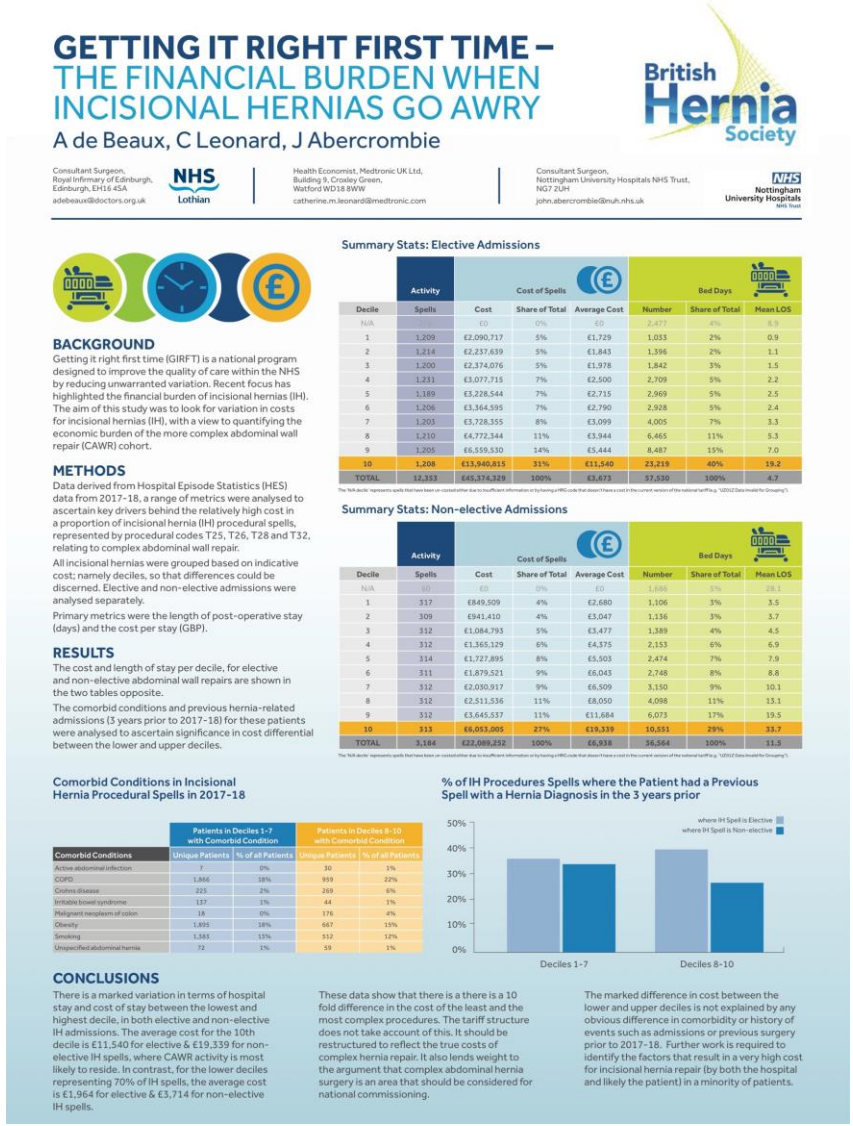
Closing time is not coffee time

Meticulous attention to surgical technique remains important, not just when in the abdomen, but also when closing the abdominal wall. Closing time is not coffee time!

Financial burden of incisional hernia is huge



GETTING IT RIGHT FIRST TIME – THE FINANCIAL BURDEN WHEN INCISIONAL HERNIAS GO AWRY

British Hernia Society

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BACKGROUND

Getting it right first time (GIRFT) is a national program designed to improve the quality of care within the NHS by reducing unwarranted variation. Recent focus has highlighted the financial burden of incisional hernias (IH). The aim of this study was to look for variation in costs for incisional hernias (IH), with a view to quantifying the economic burden of the more complex abdominal wall repair (CAWR) cohort.

METHODS

Data derived from Hospital Episode Statistics (HES) data from 2017-18, a range of metrics were analysed to ascertain key drivers behind the relatively high cost in a proportion of incisional hernia (IH) procedural spells, represented by procedural codes T25, T26, T28 and T32, relating to complex abdominal wall repair.

All incisional hernias were grouped based on indicative cost; namely deciles, so that differences could be discerned. Elective and non-elective admissions were analysed separately.

Primary metrics were the length of post-operative stay (days) and the cost per stay (GBP).

RESULTS

The cost and length of stay per decile, for elective and non-elective abdominal wall repairs are shown in the two tables opposite.

The comorbid conditions and previous hernia-related admissions (3 years prior to 2017-18) for these patients were analysed to ascertain significance in cost differential between the lower and upper deciles.

Summary Stats: Elective Admissions

	Activity	Cost of Spells			Bed Days		
Decile	Spells	Cost	Share of Total	Average Cost	Number	Share of Total	Mean LOS
N/A	278	£0	0%	£0	2,477	4%	8.9
1	1,209	£2,090,717	5%	£1,729	1,033	2%	0.9
2	1,214	£2,237,639	5%	£1,843	1,396	2%	1.1
3	1,200	£2,374,076	5%	£1,978	1,842	3%	1.5
4	1,231	£3,077,715	7%	£2,500	2,709	5%	2.2
5	1,189	£3,228,544	7%	£2,715	2,969	5%	2.5
6	1,206	£3,364,595	7%	£2,790	2,928	5%	2.4
7	1,203	£3,728,355	8%	£3,099	4,005	7%	3.3
8	1,210	£4,772,344	11%	£3,944	6,465	11%	5.3
9	1,205	£6,559,530	14%	£5,444	8,487	15%	7.0
10	1,208	£13,940,815	31%	£11,540	23,219	40%	19.2
TOTAL	12,353	£45,374,329	100%	£3,673	57,530	100%	4.7

The 'N/A decile' represents spells that have been un-costed either due to insufficient information or by having a HRG code that doesn't have a cost in the current version of the national tariff (e.g. "U2112 Data Invalid for Grouping").

Summary Stats: Non-elective Admissions

	Activity	Cost of Spells			Bed Days		
Decile	Spells	Cost	Share of Total	Average Cost	Number	Share of Total	Mean LOS
N/A	60	£0	0%	£0	1,686	5%	28.1
1	317	£849,509	4%	£2,680	1,106	3%	3.5
2	309	£941,410	4%	£3,047	1,136	3%	3.7
3	312	£1,084,793	5%	£3,477	1,389	4%	4.5
4	312	£1,365,129	6%	£4,375	2,153	6%	6.9
5	314	£1,727,895	8%	£5,503	2,474	7%	7.9
6	311	£1,879,521	9%	£6,043	2,748	8%	8.8
7	312	£2,030,917	9%	£6,509	3,150	9%	10.1
8	312	£2,511,536	11%	£8,050	4,098	11%	13.1
9	312	£3,645,537	11%	£11,684	6,073	17%	19.5
10	313	£6,053,005	27%	£19,339	10,551	29%	33.7
TOTAL	3,184	£22,089,252	100%	£6,938	36,564	100%	11.5

The 'N/A decile' represents spells that have been un-costed either due to insufficient information or by having a HRG code that doesn't have a cost in the current version of the national tariff (e.g. "U2112 Data Invalid for Grouping").

Comorbid Conditions in Incisional Hernia Procedural Spells in 2017-18

	Patients in Deciles 1-7 with Comorbid Condition		Patients in Deciles 8-10 with Comorbid Condition	
Comorbid Conditions	Unique Patients	% of all Patients	Unique Patients	% of all Patients
Active abdominal infection	7	0%	30	1%
COPD	1,866	18%	959	22%
Crohns disease	225	2%	269	6%
Irritable bowel syndrome	137	1%	44	1%
Malignant neoplasm of colon	18	0%	176	4%
Obesity	1,895	18%	667	15%
Smoking	1,583	15%	512	12%
Unspecified abdominal hernia	72	1%	59	1%

% of IH Procedures Spells where the Patient had a Previous Spell with a Hernia Diagnosis in the 3 years prior

CONCLUSIONS

There is a marked variation in terms of hospital stay and cost of stay between the lowest and highest decile, in both elective and non-elective IH admissions. The average cost for the 10th decile is £11,540 for elective & £19,339 for non-elective IH spells, where CAWR activity is most likely to reside. In contrast, for the lower deciles representing 70% of IH spells, the average cost is £1,964 for elective & £3,714 for non-elective IH spells.

These data show that there is a there is a 10 fold difference in the cost of the least and the most complex procedures. The tariff structure does not take account of this. It should be restructured to reflect the true costs of complex hernia repair. It also lends weight to the argument that complex abdominal hernia surgery is an area that should be considered for national commissioning.

The marked difference in cost between the lower and upper deciles is not explained by any obvious difference in comorbidity or history of events such as admissions or previous surgery prior to 2017-18. Further work is required to identify the factors that result in a very high cost for incisional hernia repair (by both the hospital and likely the patient) in a minority of patients.

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1	1,209	£2,090,717	5%	£1,729	1,033	2%	0.9
2	1,214	£2,237,639	5%	£1,843	1,396	2%	1.1
3	1,200	£2,374,076	5%	£1,978	1,842	3%	1.5
4	1,231	£3,077,715	7%	£2,500	2,709	5%	2.2
5	1,189	£3,228,544	7%	£2,715	2,969	5%	2.5
6	1,206	£3,364,595	7%	£2,790	2,928	5%	2.4
7	1,203	£3,728,355	8%	£3,099	4,005	7%	3.3
8	1,210	£4,772,344	11%	£3,944	6,465	11%	5.3
9	1,205	£6,559,530	14%	£5,444	8,487	15%	7.0
10	1,208	£13,940,815	31%	£11,540	23,219	40%	19.2
TOTAL	12,353	£45,374,329	100%	£3,673	57,530	100%	4.7

The 'N/A decile' represents spells that have been un-costed either due to insufficient information or by having a HRG code that doesn't have a cost in the current version of the national tariff (e.g. "U2112 Data Invalid for Grouping").

Summary Stats: Non-elective Admissions

	Activity	Cost of Spells			Bed Days		
Decile	Spells	Cost	Share of Total	Average Cost	Number	Share of Total	Mean LOS
N/A	60	£0	0%	£0	1,686	5%	28.1
1	317	£849,509	4%	£2,680	1,106	3%	3.5
2	309	£941,410	4%	£3,047	1,136	3%	3.7
3	312	£1,084,793	5%	£3,477	1,389	4%	4.5
4	312	£1,365,129	6%	£4,375	2,153	6%	6.9
5	314	£1,727,895	8%	£5,503	2,474	7%	7.9
6	311	£1,879,521	9%	£6,043	2,748	8%	8.8
7	312	£2,030,917	9%	£6,509	3,150	9%	10.1
8	312	£2,511,536	11%	£8,050	4,098	11%	13.1
9	312	£3,645,537	11%	£11,684	6,073	17%	19.5
10	313	£6,053,005	27%	£19,339	10,551	29%	33.7
TOTAL	3,184	£22,089,252	100%	£6,938	36,564	100%	11.5

An ounce of prevention is worth a pound of cure

Patient factors rarely amenable to modification

- Can not be changed
  - Cancer pathways
  - Diagnosis to surgery – 31/62
  - Physiology of the abdo wall
  - Wound healing process
  - Most patient risk factors
  - Many periop risk factors

A Risk Model and Cost Analysis of Incisional Hernia After Elective Abdominal Surgery Based on 12,373 Cases

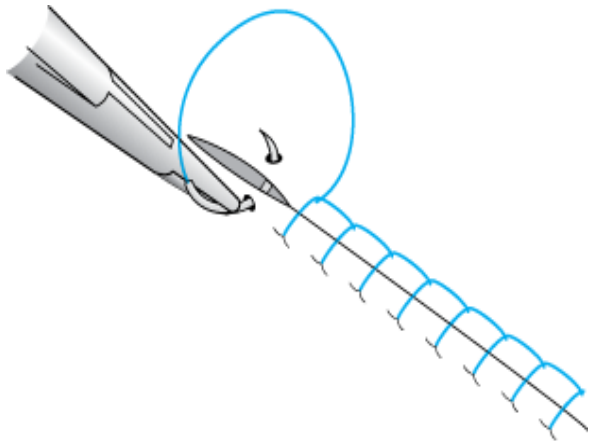
TABLE 3. Final Cox Proportional Hazards Regression and Factor Weights for Development of Postoperative Incisional Hernia (*Ann Surg* 2016;263:1010–1017)

Risk Factor	Hazard Ratio (95% CI)	*P*	Risk Score
Hispanic or Native American	2.94 (1.76–4.90)	<0.001	3
Concurrent ostomy/fistula takedown	2.76 (2.00–3.79)	<0.001	3
Recent chemotherapy	2.04 (1.53–2.71)	<0.001	2
Obesity	1.96 (1.57–2.46)	<0.001	2
Bariatric procedure	1.78 (1.19–2.66)	0.004	2
History of alcohol abuse	1.74 (0.92–3.29)	0.084	2
White	1.74 (1.35–2.25)	<0.001	2
History of smoking	1.74 (1.43–2.11)	<0.001	2
Proctectomy	1.66 (1.16–2.38)	0.005	2
History of liver disease	1.60 (1.25–2.03)	<0.001	2
Acute inflammatory process	1.48 (1.10–1.98)	0.009	1
Partial colectomy	1.45 (1.14–1.83)	0.002	1
Small bowel resection	1.43 (1.07–1.92)	0.014	1
History surgical wound complication	1.43 (1.10–1.86)	0.007	1
Concurrent ostomy creation	1.37 (1.05–1.79)	0.018	1
Malnutrition	1.33 (0.99–1.80)	0.056	1
Age >45 yr	1.26 (1.00–1.61)	0.050	1
Cardiovascular disease	0.76 (0.59–0.98)	0.039	0
Subtotal hysterectomy	0.58 (0.28–1.19)	0.141	N/A*
Normal weight	0.53 (0.39–0.71)	<0.001	−1
Asian	0.49 (0.23–1.03)	0.061	−1
Benign gynecologic mass	0.43 (0.29–0.64)	<0.001	−1

*Factor not weighted due to insignificant *P*. Harrell's C = 0.78.
CI indicates confidence interval; N/A, not applicable.

But technical factors are modifiable

- Can be changed
  - SSI measures
  - The incision
  - The suture technique
  - Reinforcement



GLOBAL GUIDELINES FOR THE PREVENTION OF SURGICAL SITE INFECTION

World Health Organization

Strong guideline recommendations

- Patients with known nasal carriage of *S. aureus* should receive **intranasal applications of mupirocin 2% ointment with or without a combination of chlorhexadine gluconate body wash.**
- **Mechanical bowel preparation alone (without the administration of oral antibiotics) should NOT be used** in adult patients undergoing elective colorectal surgery.
- In patients undergoing any surgical procedure, **hair should either NOT be removed or, if absolutely necessary, should only be removed with a clipper**. Shaving is strongly discouraged at all times, whether preoperatively or in the operating room.
- **Surgical antibiotic prophylaxis (SAP) should be administered before surgical incision**, when indicated.
- **SAP should be administered within 120 min before incision**, while considering the half-life of the antibiotic.
- **Surgical hand preparation should be performed** either by scrubbing with a suitable antimicrobial soap and water or using a suitable alcohol-based handrub before donning sterile gloves.
- **Alcohol-based antiseptic solutions based on CHG for surgical site skin preparation should be used** in patients undergoing surgical procedures.
- Adult patients undergoing general anaesthesia with endotracheal intubation for surgical procedures should receive **80% fraction of inspired oxygen intraoperatively** and, if feasible, in the immediate postoperative period for 2–6 h.
- **Surgical antibiotic prophylaxis administration should not be prolonged** after completion of the operation.

Conditional guideline recommendations

Adhesive drapes	Plastic adhesive incise drapes with or without antimicrobial properties should **not** be used for the purpose of preventing SSI.
Wound protectors	Consider the use of wound protector devices in clean-contaminated, contaminated and dirty abdominal surgical procedures for the purpose of reducing the rate of SSI.
Saline wound irrigation	There is insufficient evidence to recommend for or against saline irrigation of incisional wounds for the purpose of preventing SSI.
Povidone iodine irrigation	Consider the use of irrigation of the incisional wound with an aqueous povidone iodine solution before closure for the purpose of preventing SSI, particularly in clean and clean-contaminated wounds.
Antibiotic irrigation	Antibiotic incisional wound irrigation before closure should **not** be used for the purpose of preventing SSI.
Neg pressure wound therapy	Prophylactic negative pressure wound therapy may be used on primarily closed surgical incisions in high-risk wounds and, taking resources into account, for the purpose of preventing SSI.
Coated sutures	Triclosan-coated sutures may be used for the purpose of reducing the risk of SSI, independent of the type of surgery.

Incision planning

Hernia (2015) 19:1–24
DOI 10.1007/s10029-014-1342-5

REVIEW

European Hernia Society guidelines on the closure of abdominal wall incisions

F. E. Muysoms · S. A. Antoniou · K. Bury · G. Campanelli · J. Conze · D. Cuccurullo · A. C. de Beaux · E. B. Deerenberg · B. East · R. H. Fortelny · J.-F. Gillion · N. A. Henriksen · L. Israelsson · A. Jairam · A. Jänes · J. Jeekel · M. López-Cano · M. Miserez · S. Morales-Conde · D. L. Sanders · M. P. Simons · M. Śmietański · L. Venclauskas · F. Berrevoet

Received: 11 October 2014 / Accepted: 29 December 2014 / Published online: 25 January 2015

Abstract

Background The material and the surgical technique used to close an abdominal wall incision are important determinants of the risk of developing an incisional hernia. Optimising closure of abdominal wall incisions holds a potential to prevent patients suffering from incisional hernias and for important costs savings in health care.

Methods The European Hernia Society formed a Guidelines Development Group to provide guidelines for all surgical specialists who perform abdominal incisions in adult patients on the materials and methods used to close the abdominal wall. The guidelines were developed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach and methodological guidance was taken from Scottish Intercollegiate Guidelines Network (SIGN). The literature search included publications up to April 2014. The guidelines were written using the AGREE II instrument. An update of these guidelines is planned for 2017.

Results For many of the Key Questions that were studied no high quality data was detected. Therefore, some strong recommendations could be made but, for many Key Questions only weak recommendations or no recommendation could be made due to lack of sufficient evidence.

Recommendations To decrease the incidence of incisional hernias it is strongly recommended to utilise a non-midline approach to a laparotomy whenever possible. For elective midline incisions, it is strongly recommended to perform a continuous suturing technique and to avoid the use of rapidly absorbable sutures. It is suggested using a slowly absorbable monofilament suture in a single layer aponeurotic closure technique without separate closure of the peritoneum. A small bites technique with a suture to wound length (SL/WL) ratio at least 4/1 is the current recommended

Meeting presentation: The EHS guidelines on the closure of abdominal wall incisions were presented during the 36th Annual Congress of the European Hernia Society in Edinburgh on May 31st 2014.

Electronic supplementary material The online version of this article (doi:10.1007/s10029-014-1342-5) contains supplementary material, which is available to authorized users.

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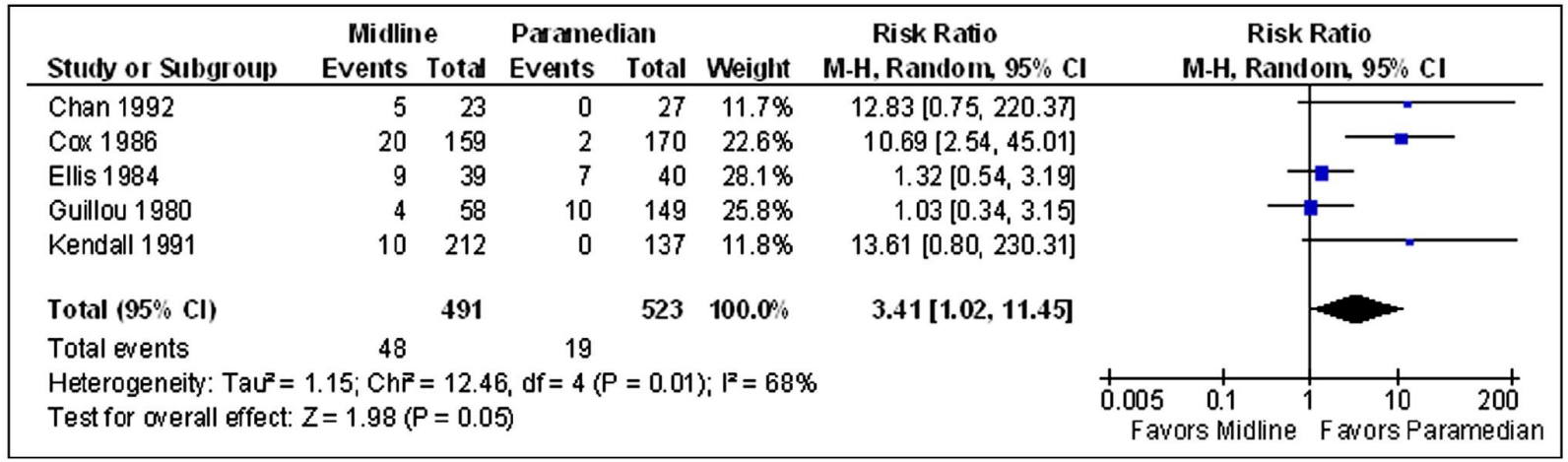


Figure 4 A Forrest plot comparing the hernia rate in midline incisions versus paramedian incisions.

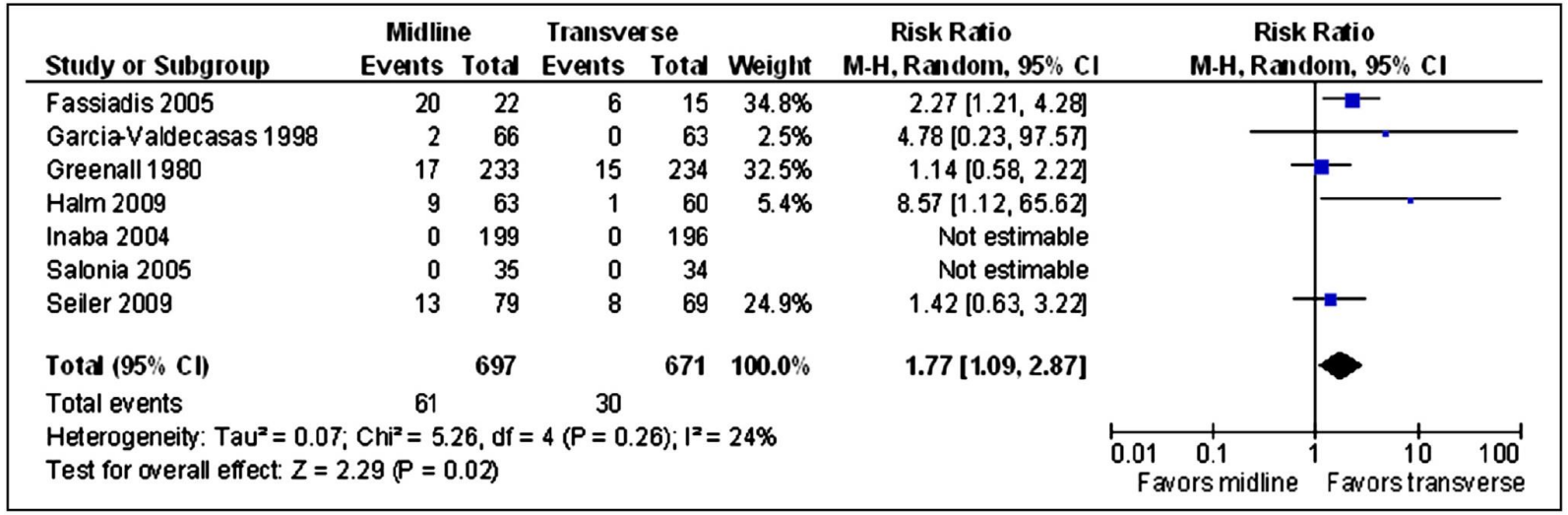


Figure 5 A Forrest plot comparing the hernia rate in midline incisions versus transverse incisions.

Suture technique - small bite closure

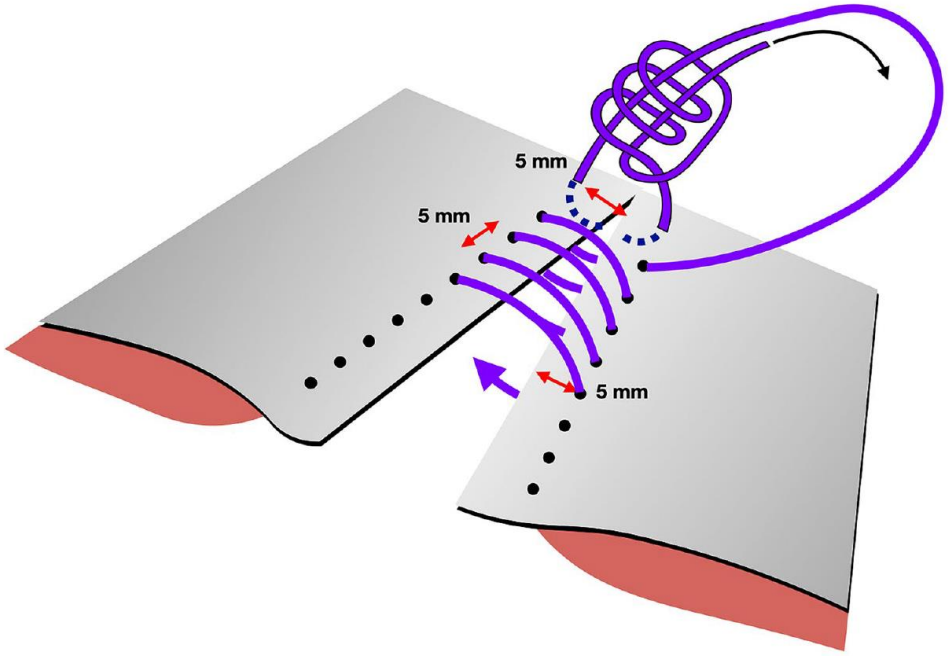
Arch Surg. 2009 Nov;144(11):1056-9. doi: 10.1001/archsurg.2009.189.

Effect of stitch length on wound complications after closure of midline incisions: a randomized controlled trial.

Millbourn D[1], Cengiz Y, Israelsson LA.

Table 2. Wound Complications Related to Stitch Length

Complication	Stitch Length		*P* Value[a]
	Long	Short	
Wound dehiscence, No. (%) of patients	1/381 (0.3)	0/356	>.99
Surgical site infection, No. (%)	35/343 (10.2)	17/326 (5.2)	.02
Incisional hernia, No. (%)	49/272 (18.0)	14/250 (5.6)	<.001

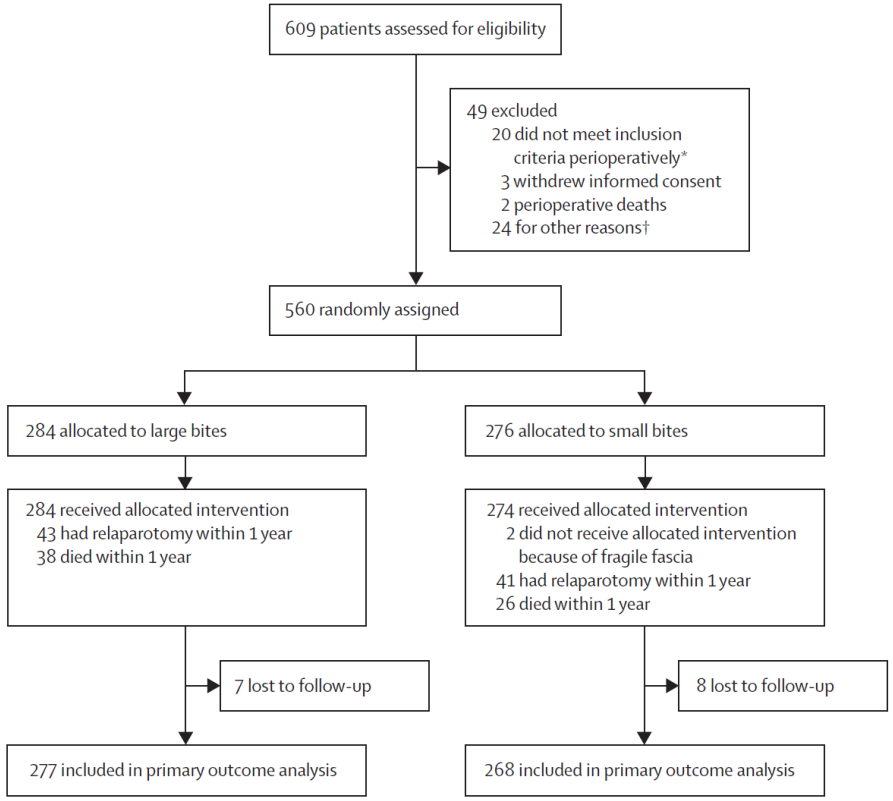


Suture technique - small bite closure

Small bites versus large bites for closure of abdominal midline incisions (STITCH): a double-blind, multicentre, randomised controlled trial

Eva B Deerenberg, Joris J Harlaar*, Ewout W Steyerberg, Harold E Lont, Helena C van Doorn, Joos Heisterkamp, Bas PL Wijnhoven, Willem R Schouten, Huib A Cense, Hein BAC Stockmann, Frits J Berends, F Paul HLJ Dijkhuizen, Roy S Dwarkasing, An P Jairam, Gabrielle H van Ramshorst, Gert-Jan Kleinrensink, Johannes Jeekel, Johan F Lange*

Lancet 2015; 386: 1254–60



	Large bites group (n=284)	Small bites group (n=276)
Sex		
Male	139 (49%)	137 (50%)
Female	145 (51%)	139 (50%)
Age (years)	63 (54–71)	62 (53–72)
BMI (kg/m²)*	24 (22–27)	24 (22–27)
Smoking	65 (23%)	77 (28%)
Diabetes mellitus	39 (14%)	29 (11%)
COPD	27 (10%)	44 (16%)
Cardiovascular disease	116 (41%)	101 (37%)
Corticosteroid use	18 (6%)	28 (10%)
Non-incisional hernias†	34 (12%)	37 (13%)
Aneurysm abdominal aorta	12 (4%)	13 (5%)
Previous laparotomy	43 (15%)	49 (18%)
ASA classification		
1	58 (20%)	61 (22%)
2	183 (64%)	162 (59%)
≥3	43 (15%)	53 (19%)
Preoperative chemotherapy	75 (26%)	62 (22%)
Preoperative radiotherapy	55 (19%)	59 (21%)
Type of surgery		
Gynaecological	41 (14%)	41 (15%)
Upper gastrointestinal	89 (31%)	74 (27%)
Lower gastrointestinal	133 (47%)	140 (51%)
Vascular	21 (7%)	21 (8%)

	Large bites group (n=284)	Small bites group (n=276)	p value
Patients with postoperative complications	129 (45%)	125 (45%)	1·000
Ileus	33 (12%)	28 (10%)	0·590
Pneumonia	40 (14%)	35 (13%)	0·710
Cardiac event	30 (11%)	25 (9%)	0·573
Surgical site infection*	68 (24%)	58 (21%)	0·419
Superficial incisional	33 (12%)	23 (8%)	0·207
Deep incisional	12 (4%)	8 (3%)	0·496
Organ or space	23 (8%)	27 (10%)	0·554
Burst abdomen	2 (1%)	4 (1%)	0·444
Length of hospital stay (days)	14 (24)	15 (35)	0·585
Incisional hernia @ 1 year	57 (21%)	35 (13%)	0.022

Suture technique - small bite closure

Effects of the short stitch technique for midline abdominal closure on incisional hernia (ESTOIH): randomized clinical trial

René H. Fortelny[1,2,*], Dorian Andrade[3], Malte Schirren[3], Petra Baumann[4], Stefan Riedl[5], Claudia Reisensohn[5], Jan Ludolf Kewer[6], Jessica Hoelderle[6], Andreas Shamiyeh[7], Bettina Klugsberger[7], Theo David Maier[8], Guido Schumacher[9], Ferdinand Köckerling[10], Ursula Pession[11], Anna Hofmann[1] and Markus Albertsmeier[3]

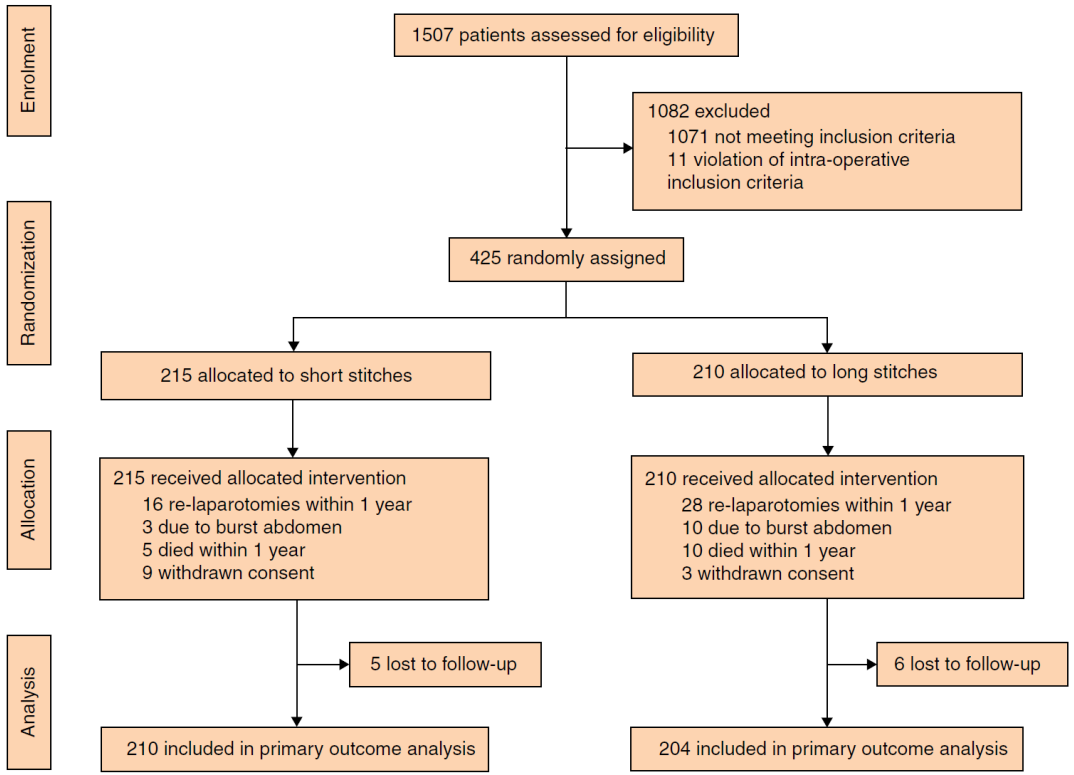


Table 4 Multiple logistic regression models for incisional hernia and the combined endpoint of incisional hernia and burst abdomen

	OR (95% c.i.)	*P* value
Incisional hernia		
Stitch group: long stitches *versus* short stitches	1.974 (0.771–5.052)	0.156
Incisional hernia or burst abdomen		
Stitch group: long stitches *versus* short stitches	2.545 (1.174–5.519)	0.020
BMI: ≥ 30 kg/m^2 *versus* < 30 kg/m^2	2.813 (1.174–6.736)	0.018

BJS, 2022, **109**, 839–845

Small bite closure – EHS

KQ3 What is the preferred strategy for closing a laparotomy?

Statement: In the available studies of acceptable quality, no superiority of one specific suture material or continuous *versus* interrupted technique could be shown. The combination of a continuous small-bites suturing technique with a slowly absorbable suture reduces the risk of incisional hernia.

Recommendation: A continuous small-bites suturing technique with a slowly absorbable suture is suggested for closure of elective midline incisions.

Quality of evidence: XX00 (low)

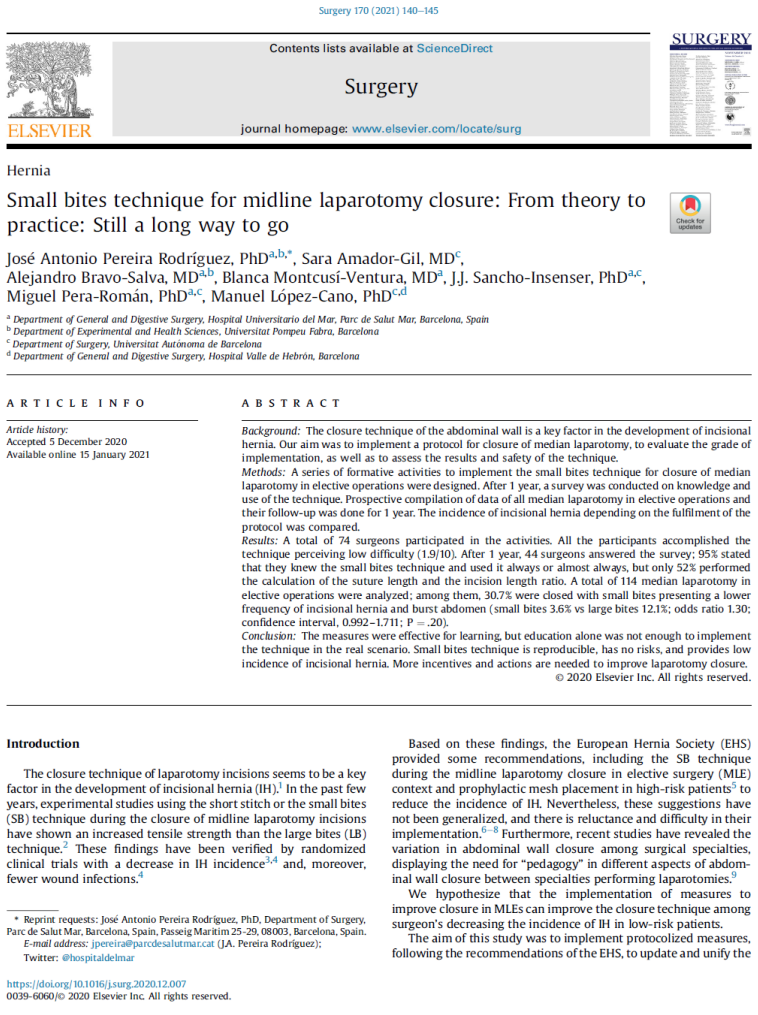
Strength of recommendation: Weak

BJS, 2022, 1–12
https://doi.org/10.1093/bjs/znac302
Guideline

OXFORD

Updated guideline for closure of abdominal wall incisions from the European and American Hernia Societies

Small bite closure – widely adopted?



Surgery 170 (2021) 140–145

Contents lists available at ScienceDirect

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journal homepage: www.elsevier.com/locate/surg

Hernia

Small bites technique for midline laparotomy closure: From theory to practice: Still a long way to go

José Antonio Pereira Rodríguez, PhD[a,b,*], Sara Amador-Gil, MD[c], Alejandro Bravo-Salva, MD[a,b], Blanca Montcusí-Ventura, MD[a], J.J. Sancho-Insenser, PhD[a,c], Miguel Pera-Román, PhD[a,c], Manuel López-Cano, PhD[c,d]

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ARTICLE INFO

Article history:
Accepted 5 December 2020
Available online 15 January 2021

ABSTRACT

Background: The closure technique of the abdominal wall is a key factor in the development of incisional hernia. Our aim was to implement a protocol for closure of median laparotomy, to evaluate the grade of implementation, as well as to assess the results and safety of the technique.
Methods: A series of formative activities to implement the small bites technique for closure of median laparotomy in elective operations were designed. After 1 year, a survey was conducted on knowledge and use of the technique. Prospective compilation of data of all median laparotomy in elective operations and their follow-up was done for 1 year. The incidence of incisional hernia depending on the fulfilment of the protocol was compared.
Results: A total of 74 surgeons participated in the activities. All the participants accomplished the technique perceiving low difficulty (1.9/10). After 1 year, 44 surgeons answered the survey; 95% stated that they knew the small bites technique and used it always or almost always, but only 52% performed the calculation of the suture length and the incision length ratio. A total of 114 median laparotomy in elective operations were analyzed; among them, 30.7% were closed with small bites presenting a lower frequency of incisional hernia and burst abdomen (small bites 3.6% vs large bites 12.1%; odds ratio 1.30; confidence interval, 0.992–1.711; P = .20).
Conclusion: The measures were effective for learning, but education alone was not enough to implement the technique in the real scenario. Small bites technique is reproducible, has no risks, and provides low incidence of incisional hernia. More incentives and actions are needed to improve laparotomy closure.

Introduction

The closure technique of laparotomy incisions seems to be a key factor in the development of incisional hernia (IH).[1] In the past few years, experimental studies using the short stitch or the small bites (SB) technique during the closure of midline laparotomy incisions have shown an increased tensile strength than the large bites (LB) technique.[2] These findings have been verified by randomized clinical trials with a decrease in IH incidence[3,4] and, moreover, fewer wound infections.[4]

Based on these findings, the European Hernia Society (EHS) provided some recommendations, including the SB technique during the midline laparotomy closure in elective surgery (MLE) context and prophylactic mesh placement in high-risk patients[5] to reduce the incidence of IH. Nevertheless, these suggestions have not been generalized, and there is reluctance and difficulty in their implementation.[6–8] Furthermore, recent studies have revealed the variation in abdominal wall closure among surgical specialties, displaying the need for "pedagogy" in different aspects of abdominal wall closure between specialties performing laparotomies.[9]

We hypothesize that the implementation of measures to improve closure in MLEs can improve the closure technique among surgeon's decreasing the incidence of IH in low-risk patients.

The aim of this study was to implement protocolized measures, following the recommendations of the EHS, to update and unify the

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https://doi.org/10.1016/j.surg.2020.12.007
0039-6060/

CIPHER STUDY

Proposed comparisons of surgical technique items for primary outcome analyses

Surgical technique item	Comparison	Percentage	Ratio	Excluded
Intended type of access used; n (%)	Minimally invasive Open	72% 26%	1 : 1.27	2%
Type of stoma formed; n (%)	End Loop	58% 40%	1 : 1.45	2%
Bowel used to form stoma; n (%)	Colon (descending/sigmoid) Ileum	53% 45%	1 : 1.18	2%
Stoma site pre-marked; n (%)	Preserved with pen Preserved with suture	74% 24%	1 : 3.08	2%
Anterior sheath: Shape of incision; n (%)	Cruciate or linear Circular	89% 11%	1 : 8.09	1%
Posterior sheath: incision shape; n (%)	Linear (horizontal/vertical) Cruciate	52% 42%	1 : 1.24	5%
Location of trephine; n (%)	Other than port site At port site	44% 28%	1 : 1.57	27%
Sutures used to buttress incision; n (%)	No Yes	90% 10%	1 : 10.0	0%
Stoma trephine = extraction site; n (%)	No Yes	93%) 7%)	1 : 13.3	0%
Closure of deep layer; n (%)	Large bite closure Small bite closure	41% 28%	1 : 1.46	31%

Small bite closure – widely adopted?

Surgery 170 (2021) 140–145

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Hernia

Small bites technique for midline laparotomy closure: From practice: Still a long way to go

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…020.12.007

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Type of stoma formed; n (%)	End Loop	58% 40%	1 : 1.45	2%
Bowel used to form stoma; n (%)	Colon (descending/sigmoid) Ileum	53% 45%	1 : 1.18	2%
Stoma site pre-marked; n (%)	Preserved with pen Preserved with suture	74% 24%	1 : 3.08	2%
Anterior sheath: Shape of incision; n (%)	Cruciate or linear Circular	89% 11%	1 : 8.09	1%
Posterior sheath: incision shape; n (%)	Linear (horizontal/vertical) Cruciate	52% 42%	1 : 1.24	5%
Location of trephine; n (%)	Other than port site At port site	44% 28%	1 : 1.57	27%
Sutures used to buttress incision; n (%)	No Yes	90% 10%	1 : 10.0	0%
Stoma trephine = extraction site; n (%)	No Yes	93%) 7%)	1 : 13.3	0%
Closure of deep layer; n (%)	Large bite closure Small bite closure	41% 28%	1 : 1.46	31%

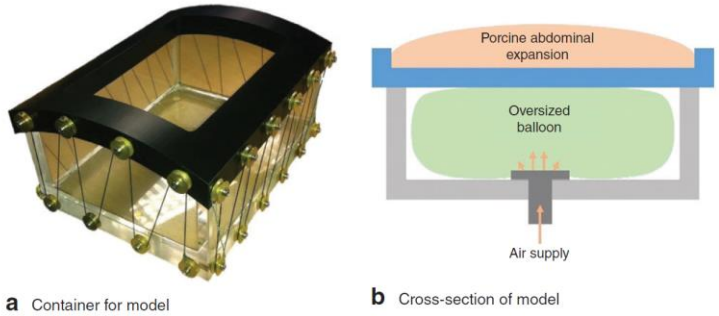
Surgeons self report that ~40% of all midline incisions closed small bites

Small bite closure – more complex?

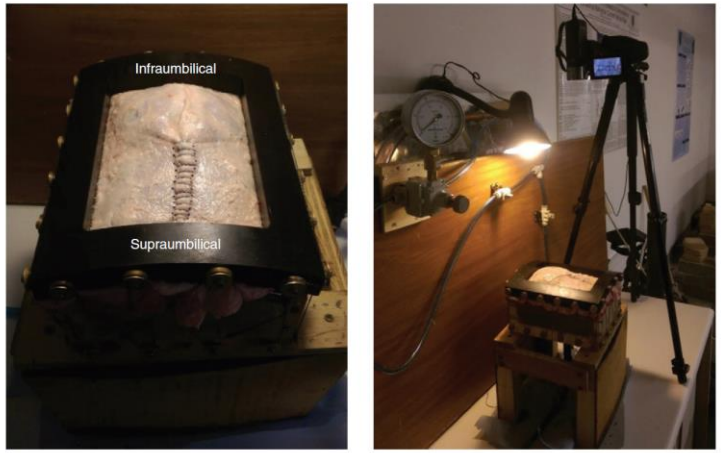
Optimized wound closure using a biomechanical abdominal model

G. M. Cooney[1], A. Kiernan[2], D. C. Winter[2,3] and C. K. Simms[1]

BJS 2018; **105**: 395–400



a Container for model **b** Cross-section of model



c Abdominal wall and suture placement **d** Overall set-up

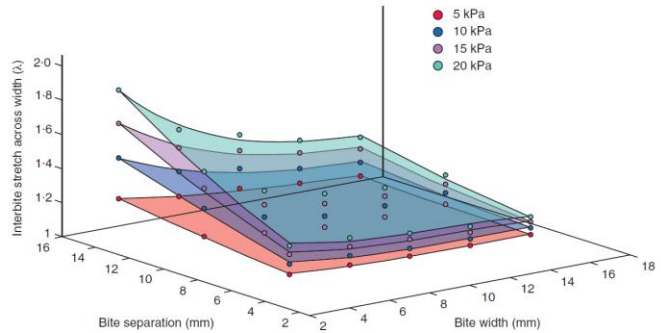


Fig. 3 Mean stretch (λ) across the incision *versus* bite separation and bite width for pressures of 5, 10, 15 and 20 kPa. Best-fit surfaces are also shown

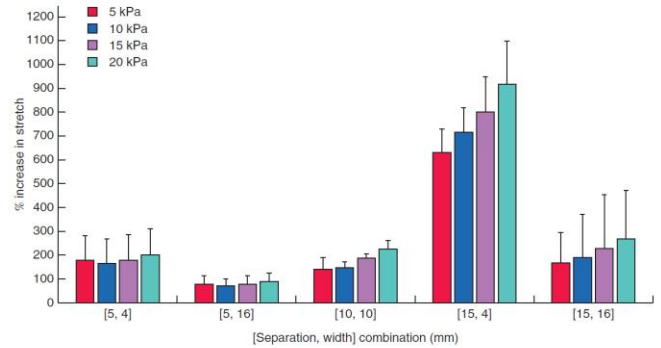


Fig. 4 Percentage increase in mean stretch (defect *versus* no defect) for different combinations of bite separation and bite width [separation, width]. Values are mean(s.d.)

Suture technique - NIHR HART Trial

STUDY PROTOCOL Open Access

Hughes Abdominal Repair Trial (HART) – Abdominal wall closure techniques to reduce the incidence of incisional hernias: study protocol for a randomised controlled trial

Cornish *et al. Trials* (2016) 17:454

J. Cornish[1], R. L. Harries[1], D. Bosanquet[1], B. Rees[1], J. Ansell[1], N. Frewer[1], P. K. Dhruva Rao[1], C. Parry[1], R. Ellis-Owen[1], S. M. Phillips[1], C. Morris[1], J. Horwood[1], M. L. Davies[1], M. M. Davies[1], R. Hargest[1], Z. Davies[1], J. Hilton[2], D. Harris[3], A. Ben-Sassi[4], R. Rajagopal[5], D. Hanratty[6], S. Islam[7], A. Watkins[7], N. Bashir[7], S. Jones[8], I. R. Russell[7], J. Torkington[1*] and on behalf of the HART Trial Management Group

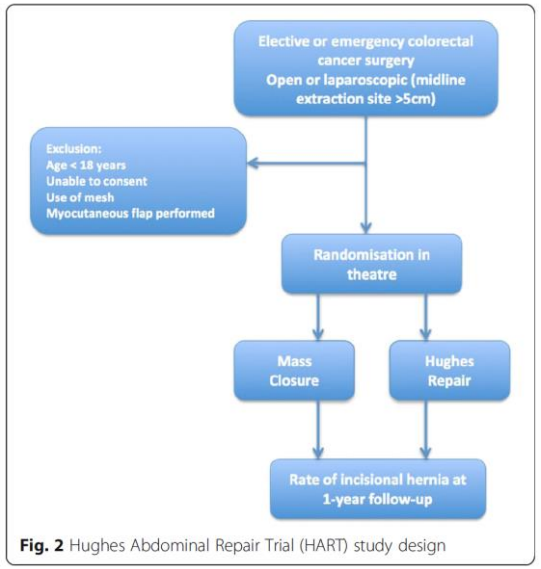


Fig. 2 Hughes Abdominal Repair Trial (HART) study design

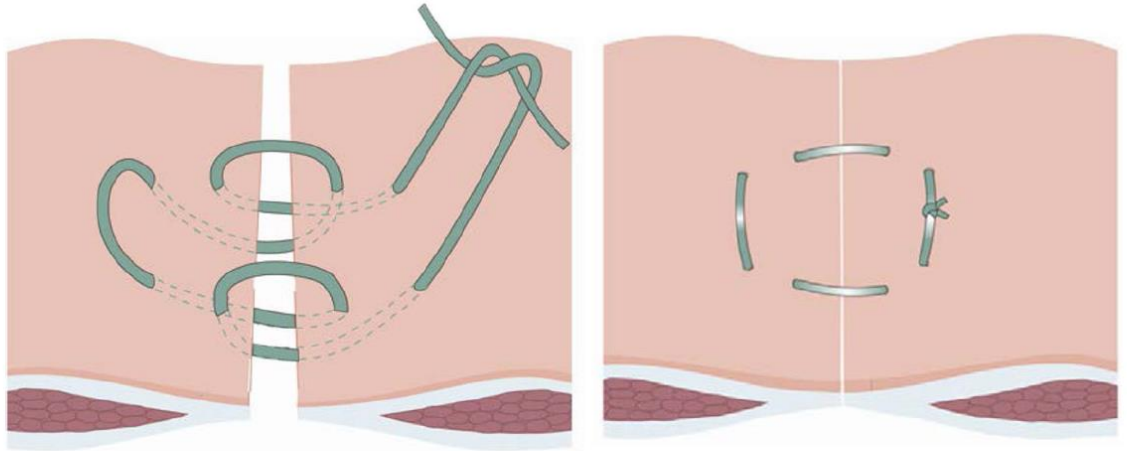


Fig. 1 Diagram showing the Hughes closure method, using a combination of standard mass closure with a series of horizontal and two vertical mattress sutures within a single suture. When the sutures are pulled to close the defect, the sutures lie both across and along the incision

Suture technique

HART
Hughes Abdominal Repair Trial

Primary objective

To compare the clinical incidence of incisional hernias over one year following colorectal cancer surgery between the Hughes and standard mass closure

Secondary objectives

- Quality of Life
- Cost-effectiveness
- Burst abdomen
- Risk factors

Tertiary objectives

- 5 year data for incisional hernia
- 5 year data for Quality of Life
- CT and CE comparison

With kind permission from Prof Jared Torkington

Suture technique

HART
Hughes Abdominal Repair Trial

Incisional hernia following colorectal cancer surgery according to suture technique: Hughes Abdominal Repair Randomized Trial (HART)

BJS, 2022, 1–8
https://doi.org/10.1093/bjs/znac198

	Hughes Closure n=401	Standard Closure n=401
Age (mean)	69	**70**
Gender (M:F)	65:35	**62:38**
BMI (mean)	27.3	**27.0**
Smokers	31 (7.7%)	**37 (9.2%)**
Stoma formation	35%	**31%**
Open surgery	171 (42.6%)	**151 (37.7%)**
Lap converted	70 (17.5%)	**59 (14.7%)**

Suture technique

HART
Hughes Abdominal Repair Trial

Incisional hernia following colorectal cancer surgery according to suture technique: Hughes Abdominal Repair Randomized Trial (HART)

BJS, 2022, 1–8
https://doi.org/10.1093/bjs/znac198

Table 2 Incisional hernia incidence by clinical examination in each group

	Hughes closure	Standard mass closure
1 year	50 of 339 (14.8)	57 of 333 (17.1)
2 years	78 of 271 (28.7)	84 of 264 (31.8)

Values are *n* (%).

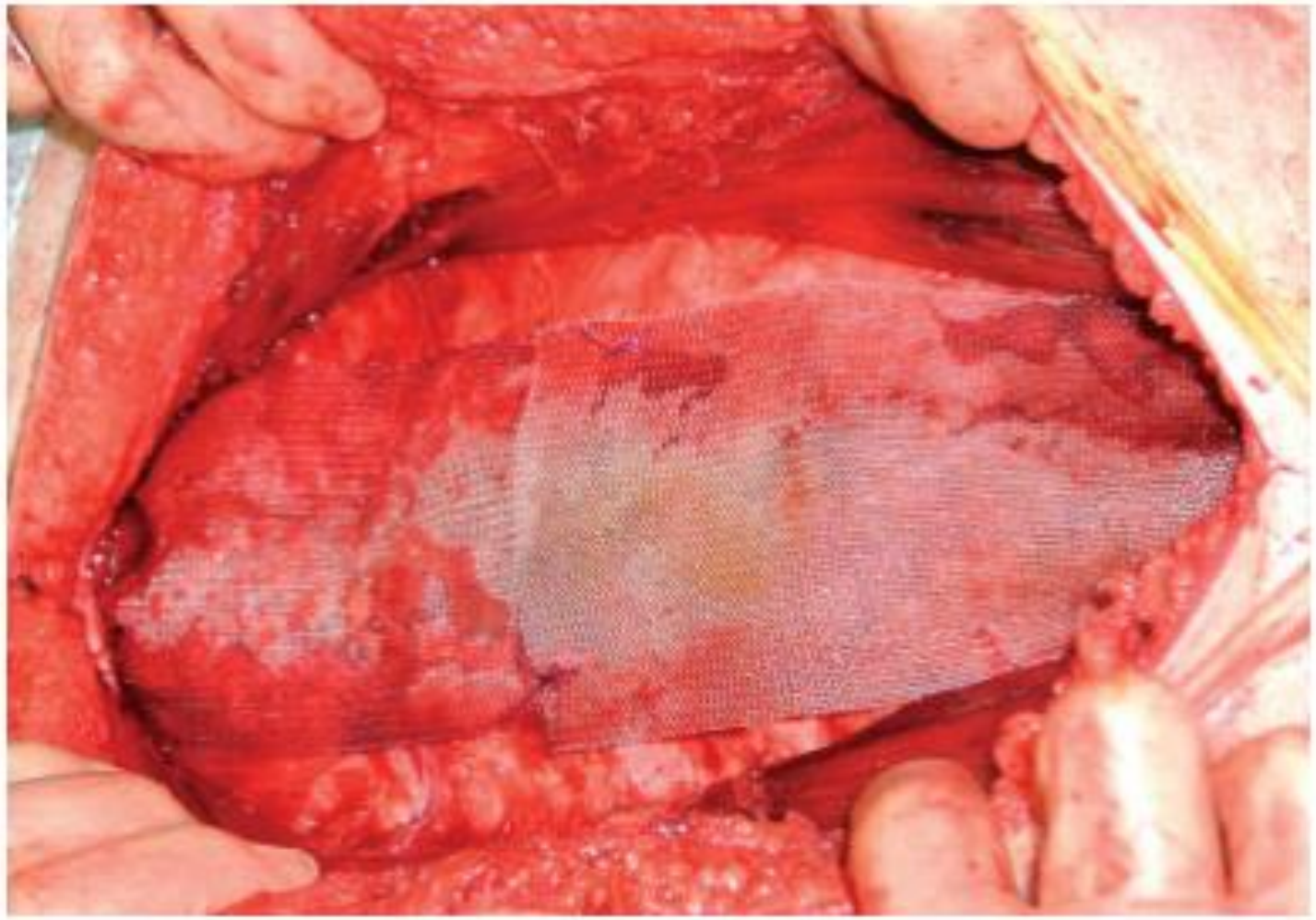
Incisional hernia by CT in each group

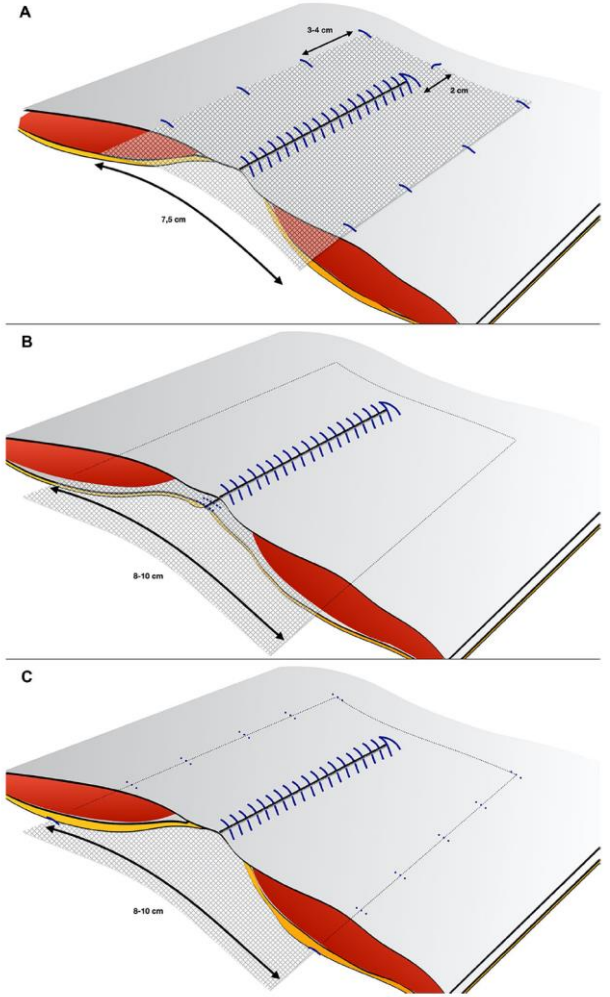
	Hughes closure	Standard Mass Closure
1 year	158 (47.0%)	165 (47.8%)

Table 5 Logistic regression model of factors influencing incisional hernia formation at 1 and 2 years

	Year 1		Year 2	
	OR	P	OR	P
Hughes closure	0.73 (0.48, 1.12)	0.165	0.79 (0.54, 1.17)	0.235
Age	1.03 (1.01, 1.05)	0.009	1.02 (1.00, 1.04)	0.023
Male sex	1.72 (1.07, 2.77)	0.027	1.48 (0.98, 2.27)	0.070
BMI	1.05 (1.01, 1.10)	0.053	1.07 (1.02, 1.10)	0.002
Radiotherapy use	3.80 (1.37, 9.45)	0.010	3.30 (1.20, 9.02)	0.020
POSSUM	0.99 (0.95, 1.03)	0.692	1.03 (1.00, 1.08)	0.034
SF-12®: PCS (baseline)	0.96 (0.92, 1.00)	0.054	0.97 (0.93,1.01)	0.096
Emergency admission	2.46 (1.07, 5.68)	0.034	2.16 (0.90, 5.19)	0.084

Mesh reinforcement

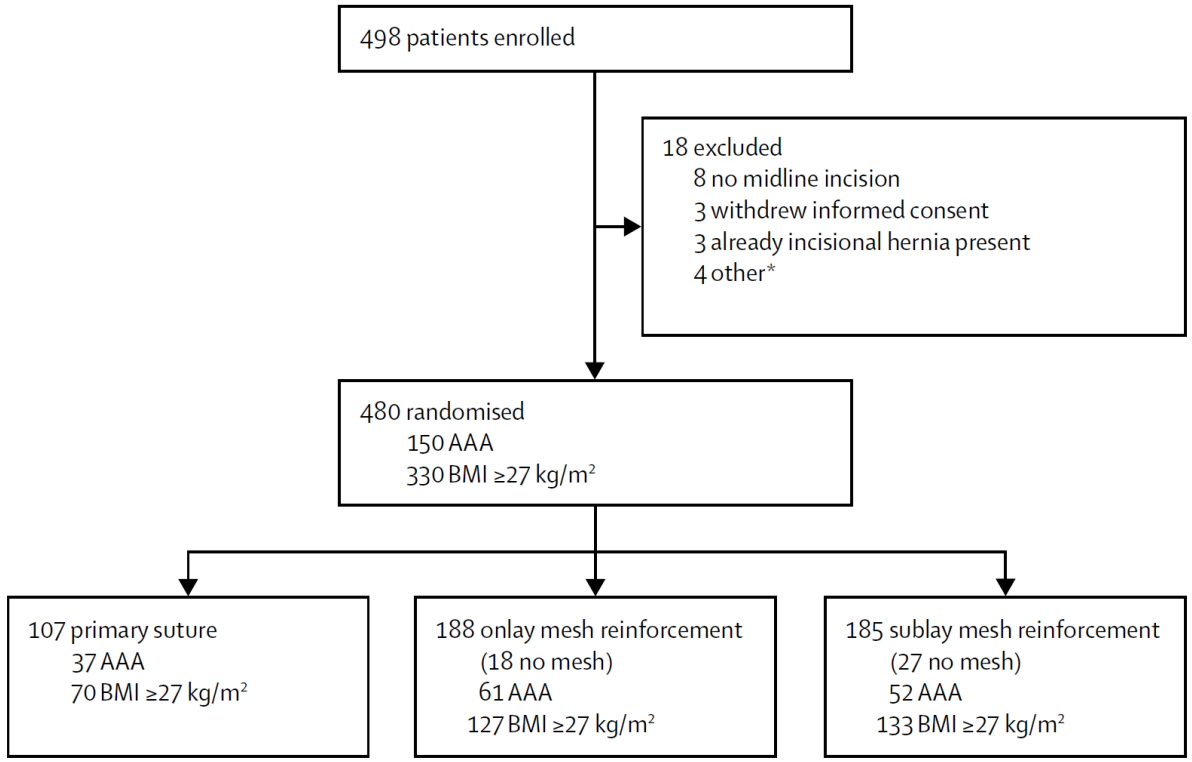




PRIMA Trial

Prevention of incisional hernia with prophylactic onlay and sublay mesh reinforcement versus primary suture only in midline laparotomies (PRIMA): 2-year follow-up of a multicentre, double-blind, randomised controlled trial

Lancet 2017; 390: 567–76



	Total (n=480)	Primary suture (n=107)	Onlay mesh reinforcement (n=188)	Sublay mesh reinforcement (n=185)
Men	292 (61%)	68 (64%)	116 (62%)	108 (58%)
Women	188 (39%)	39 (36%)	72 (38%)	77 (42%)
Age (years)	64·5 (11·2)	65·2 (10·5)	64·2 (12·3)	64·4 (10·4)
BMI (kg/m²)	30·6 (5·3)	29·8 (4·4)	30·8 (5·9)	30·8 (5·2)
Smoking	102 (21%)	17 (16%)	41 (22%)	44 (24%)
Diabetes mellitus	94 (20%)	19 (18%)	36 (19%)	39 (21%)
COPD	52 (11%)	9 (8%)	24 (13%)	19 (10%)
ASA				
I	44 (9%)	10 (9%)	21 (11%)	13 (7%)
II	234 (49%)	55 (51%)	90 (48%)	89 (48%)
III	150 (31%)	35 (33%)	54 (29%)	61 (33%)
IV	6 (1%)	1 (1%)	3 (2%)	2 (1%)
Unspecified	46 (10%)	6 (6%)	20 (11%)	20 (11%)
Previous midline incision	21 (4%)	3 (3%)	10 (5%)	8 (4%)
Other hernia	50 (10%)	13 (12%)	19 (10%)	18 (10%)
Type of operation				
Vascular	159 (33%)	39 (36%)	64 (34%)	56 (30%)
Upper gastrointestinal	65 (14%)	18 (17%)	22 (12%)	25 (14%)
Lower gastrointestinal	162 (34%)	29 (27%)	67 (36%)	66 (36%)
Hepatobiliary and pancreatic	21 (4%)	3 (3%)	8 (4%)	10 (5%)
Gynaecological	66 (14%)	15 (14%)	24 (13%)	27 (15%)
Urological	7 (1%)	3 (3%)	3 (2%)	1 (<1%)

PRIMA Trial

	Incidence (%)	Odds ratio (95% CI)	p value
All patients with follow-up to 2 years (n=480)			
Primary mesh reinforcement *vs* primary suture*	59/373 (16%) *vs* 33/107 (30%)	0·45 (0·27–0·77)	0·003
Onlay mesh reinforcement *vs* primary suture*	25/188 (13%) *vs* 33/107 (30%)	0·37 (0·20–0·69)	0·0016
Sublay mesh reinforcement *vs* primary suture*	34/185(18%) *vs* 33/107 (30%)	0·55 (0·30–1·00)	0·05
Onlay mesh reinforcement *vs* sublay mesh reinforcement†	25/188 (13%) *vs* 34/185 (18%)	1·39 (0·73–2·65)	0·31
Abdominal aortic aneurysm (n=150)			
Primary mesh reinforcement *vs* primary suture*	20/113 (17%) *vs* 16/37 (43%)	0·29 (0·12–0·67)	0·004
Onlay mesh reinforcement *vs* primary suture*	10/61 (16%) *vs* 16/37 (43%)	0·27 (0·10–0·71)	0·008
Sublay mesh reinforcement *vs* primary suture*	10/52 (19%) *vs* 16/37 (43%)	0·36 (0·13–0·93)	0·03
Onlay mesh reinforcement *vs* sublay mesh reinforcement†	10/61 (16%) *vs* 10/52 (19%)	1·04 (0·32–3·39)	0·95
BMI ≥27 kg/m² (n=330)			
Primary mesh reinforcement *vs* primary suture*	38/260 (15%) *vs* 16/70 (23%)	0·58 (0·29–1·19)	0·14
Onlay mesh reinforcement *vs* primary suture*	15/127 (12%) *vs* 16/70 (23%)	0·47 (0·21–1·06)	0·07
Sublay mesh reinforcement *vs* primary suture*	23/133 (17%) *vs* 16/70 (23%)	0·72 (0·32–1·60)	0·42
Onlay mesh reinforcement *vs* sublay mesh reinforcement†	15/127 (12%) *vs* 23/133 (17%)	1·62 (0·73–3·63)	0·24

Primary mesh reinforcement comprises both onlay and sublay mesh reinforcement. *Intention-to-treat analysis. †Per-protocol analysis.

Table 2: **Incidence of incisional hernia in all patients with 2-year follow-up and by subgroups**

Lancet 2017; 390: 567–76

PRIMA Trial

	Incidence (%)	Odds ratio (95% CI)	p value
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Table 2: Incidence of incisional hernia in all patients with 2-year follow-up and by subgroups

underpowered?

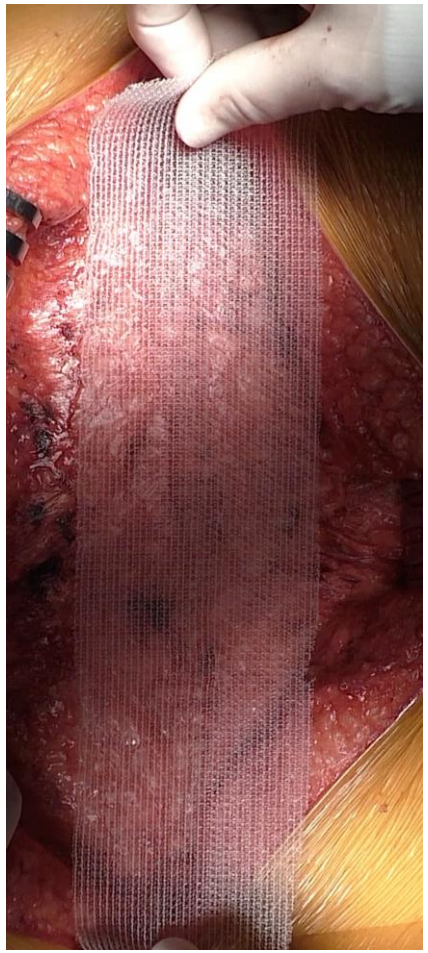
Lancet 2017; 390: 567–76

Mesh prophylaxis – the answer?

Prophylactic Mesh After Midline Laparotomy: Evidence is out There, but why do Surgeons Hesitate?

Martijn Depuydt[1] · Mathias Allaeys[1] · Luis Abreu de Carvalho[1] · Aude Vanlander[1] · Frederik Berrevoet[1]

World J Surg
https://doi.org/10.1007/s00268-020-05898-0



Study or Subgroup	PMR Events	PMR Total	PS Events	PS Total	Weight	Odds Ratio M-H, Fixed, 95% CI
abo-Ryia et al., 2013	1	32	9	32	3.3%	0.08 [0.01, 0.70]
Bali et al., 2015	0	20	6	20	2.4%	0.05 [0.00, 1.04]
Bevis et al., 2010	5	40	16	45	4.9%	0.26 [0.08, 0.79]
Caro-Tarrago et al., 2019	2	80	30	80	10.9%	0.04 [0.01, 0.19]
El-Khadrawy et al., 2009	1	20	3	20	1.1%	0.30 [0.03, 3.15]
Garcia-Urena et al., 2015	6	53	17	54	5.6%	0.28 [0.10, 0.77]
Glauser et al., 2019	26	95	46	88	13.0%	0.34 [0.19, 0.64]
Gutierrez De La Pena et al., 2003	0	44	5	44	2.0%	0.08 [0.00, 1.51]
Jairam et al., 2017	59	373	33	107	16.1%	0.42 [0.26, 0.69]
Kohler et al., 2018	5	69	15	81	4.8%	0.34 [0.12, 1.00]
Muysoms et al., 2016	0	56	16	58	6.0%	0.02 [0.00, 0.39]
Pans et al., 1998	33	144	41	144	11.8%	0.75 [0.44, 1.27]
Pizza et al., 2020	3	45	11	47	3.7%	0.23 [0.06, 0.90]
Sarr et al., 2014	32	185	38	195	11.4%	0.86 [0.51, 1.45]
Strzelczyk et al., 2006	0	36	8	38	3.0%	0.05 [0.00, 0.89]
Total (95% CI)		**1292**		**1053**	**100.0%**	**0.37 [0.30, 0.46]**
Total events	173		294			

Heterogeneity: Chi² = 36.84, df = 14 (P = 0.0008); I² = 62%
Test for overall effect: Z = 8.87 (P < 0.00001)

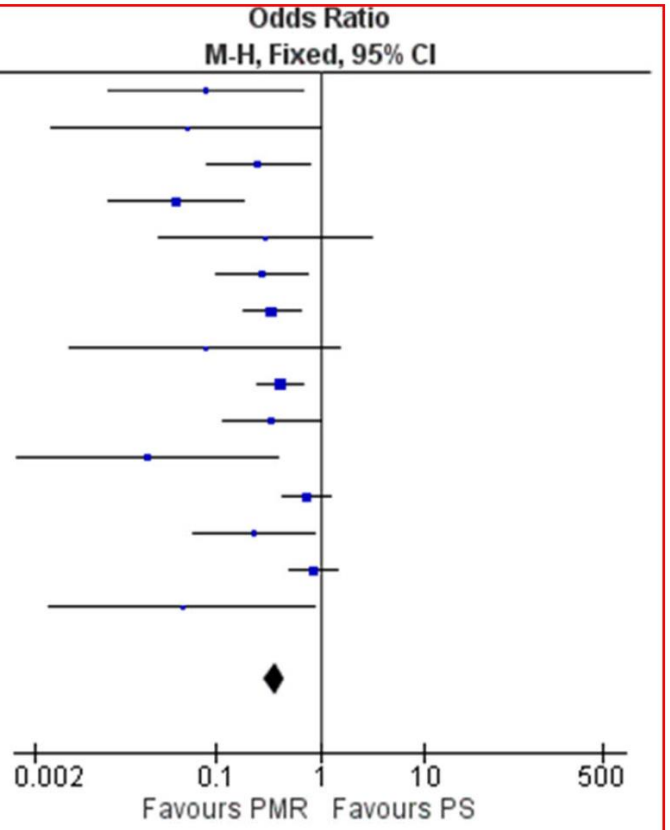


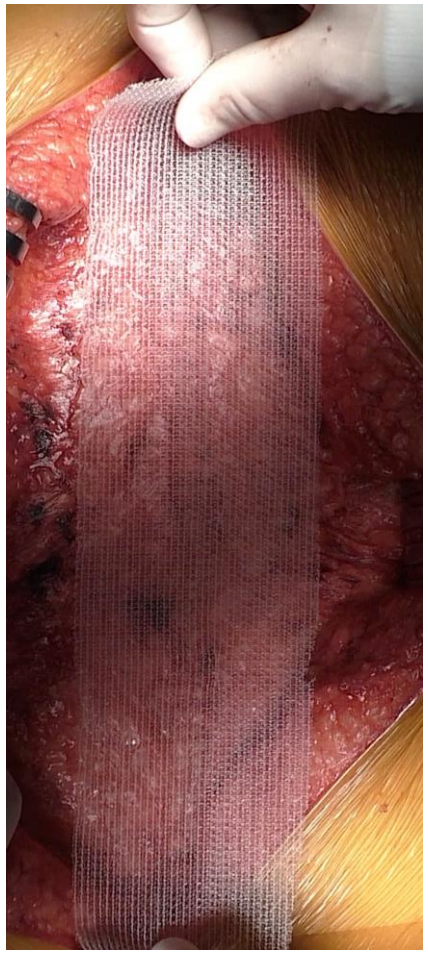
Fig. 2 Forest plot of the OR for IH incidence after laparotomy, based on RCT-studies

Mesh prophylaxis – the answer?

Prophylactic Mesh After Midline Laparotomy: Evidence is out There, but why do Surgeons Hesitate?

Martijn Depuydt[1] · Mathias Allaeys[1] · Luis Abreu de Carvalho[1] · Aude Vanlander[1] · Frederik Berrevoet[1]

World J Surg
https://doi.org/10.1007/s00268-020-05898-0



Study or Subgroup	PMR Events	PMR Total	PS Events	PS Total	Weight	Odds Ratio M-H, Fixed, 95% CI
abo-Ryia et al., 2013	5	32	5	32	5.0%	1.00 [0.26, 3.86]
Bali et al., 2015	0	20	0	20		Not estimable
Bevis et al., 2010	2	40	2	45	2.1%	1.13 [0.15, 8.43]
Caro-Tarrago et al., 2019	10	80	9	80	9.4%	1.13 [0.43, 2.94]
El-Khadrawy et al., 2009	2	20	4	20	4.3%	0.44 [0.07, 2.76]
Garcia-Urena et al., 2015	10	53	18	54	17.3%	0.47 [0.19, 1.13]
Glauser et al., 2019	4	95	1	88	1.2%	3.82 [0.42, 34.89]
Gutierrez De La Pena et al., 2003	1	44	1	44	1.2%	1.00 [0.06, 16.51]
Jairam et al., 2017	44	373	14	107	22.9%	0.89 [0.47, 1.69]
Kohler et al., 2018	11	69	18	69	18.1%	0.54 [0.23, 1.24]
Muysoms et al., 2016	1	56	3	58	3.5%	0.33 [0.03, 3.30]
Pans et al., 1998	5	144	4	144	4.6%	1.26 [0.33, 4.79]
Pizza et al., 2020	3	50	3	50	3.4%	1.00 [0.19, 5.21]
Sarr et al., 2014	22	185	7	195	7.2%	3.62 [1.51, 8.70]
Total (95% CI)		**1261**		**1006**	**100.0%**	**1.00 [0.74, 1.35]**
Total events	120		89			

Heterogeneity: $Chi^2 = 16.61$, $df = 12$ ($P = 0.16$); $I^2 = 28\%$
Test for overall effect: $Z = 0.00$ ($P = 1.00$)

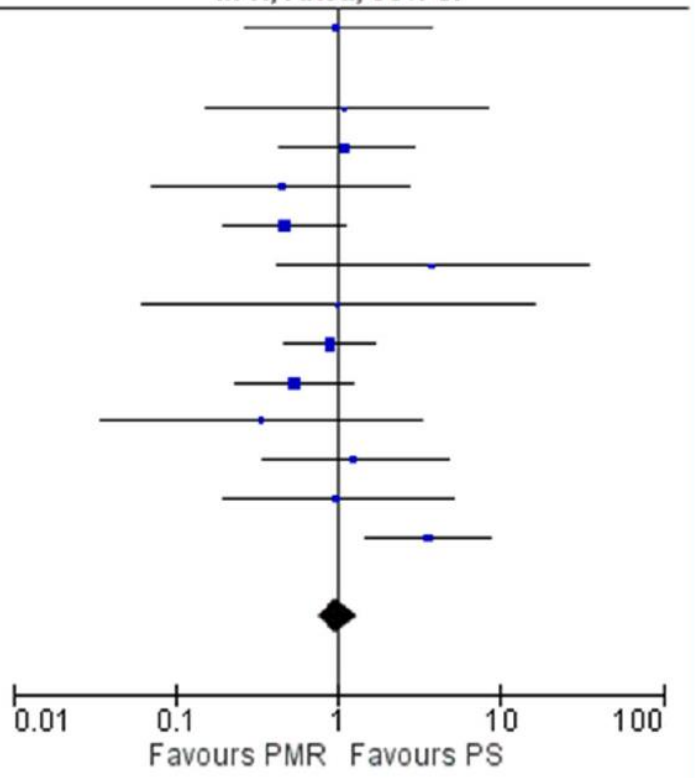


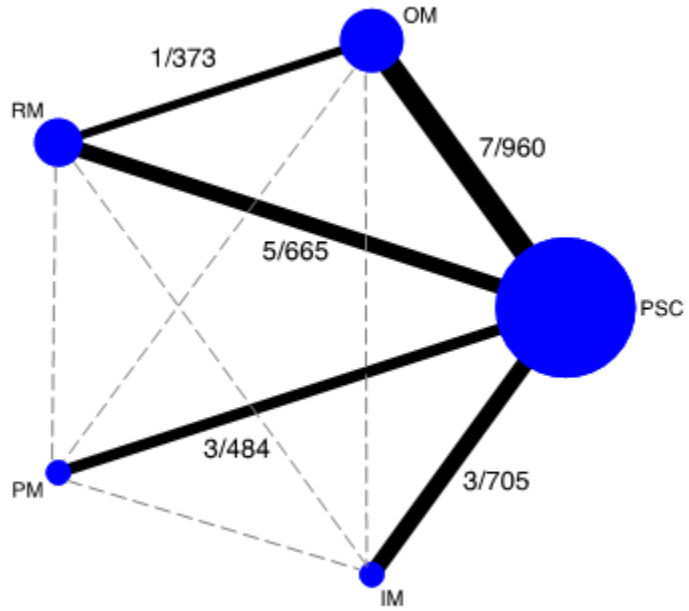
Fig. 4 Forest plot of the OR for post-operative infection (SSI and mesh), based on RCT-studies

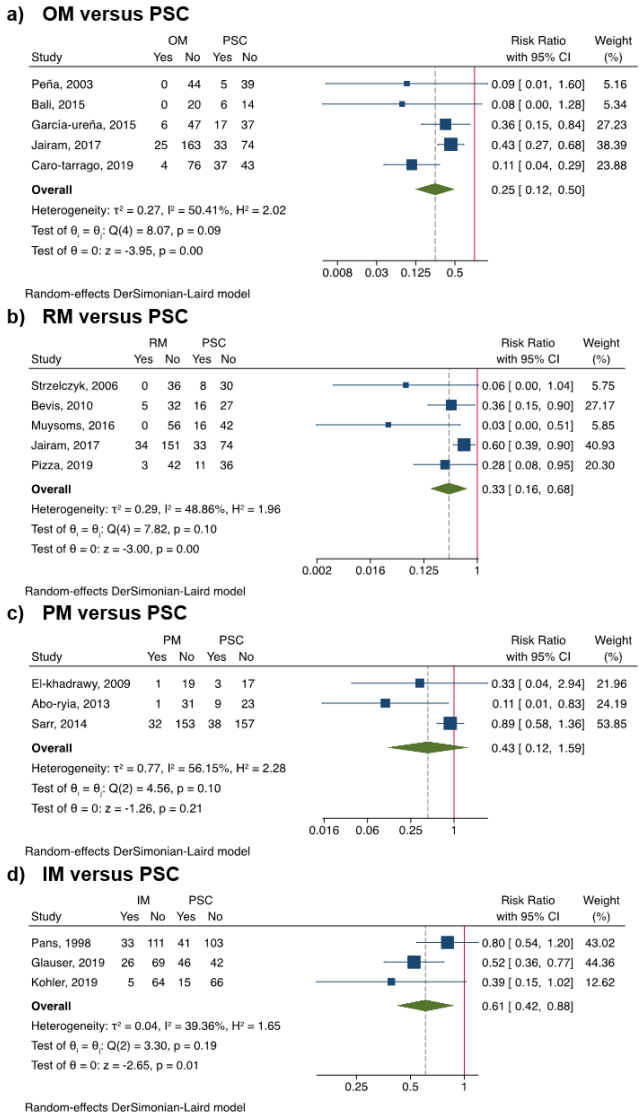
Which technique of placement?

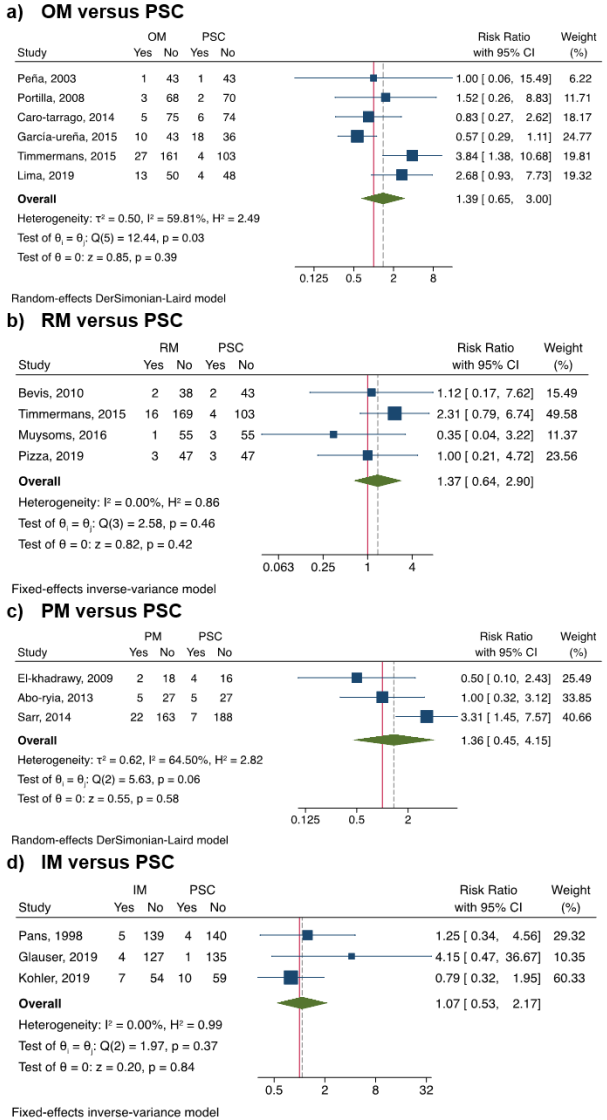
Mesh position for hernia prophylaxis after midline laparotomy: A systematic review and network meta-analysis of randomized clinical trials

Amarit Tansawet [a,b], Pawin Numthavaj [a,*], Suphakarn Techapongsatorn [a,b], Chumpon Wilasrusmee [c], John Attia [d], Ammarin Thakkinstian [a]

International Journal of Surgery 83 (2020) 144–151







Mesh reinforcement

KQ5a Is mesh augmentation beneficial for closure of elective laparotomies?

Statement: Mesh augmentation after suture closure of a midline abdominal incision reduces the rate of incisional hernia compared with primary suture closure. Studies do not show an increased risk of surgical-site infection. Data on burst abdomen and postoperative pain are limited. Currently, there are no data on mesh augmentation *versus* primary suture closure of non-midline abdominal incisions.

Recommendation: Prophylactic mesh augmentation after elective midline laparotomy can be considered to reduce the risk of incisional hernia.

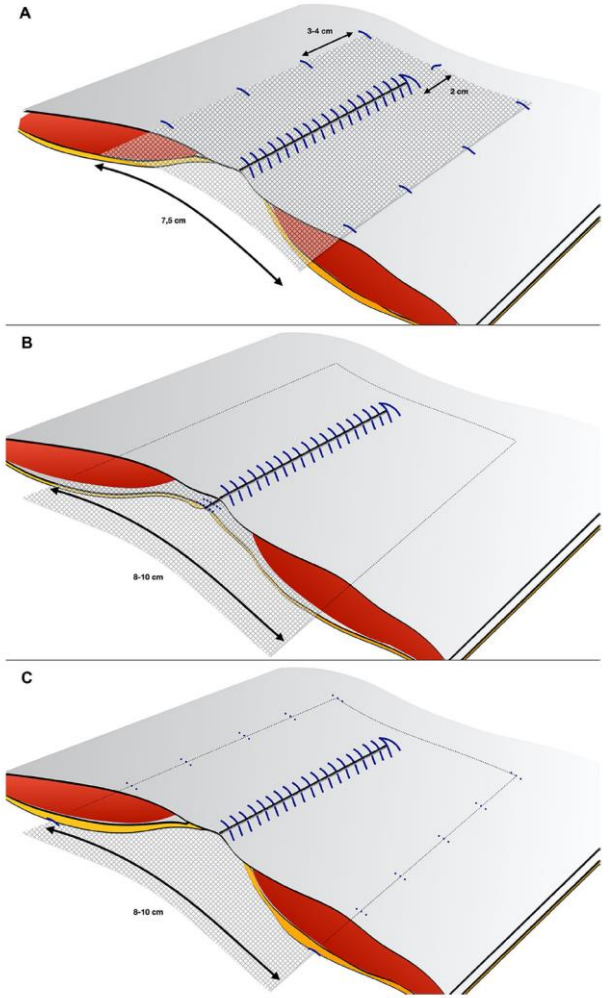
Quality of evidence: XX00 (low)

Strength of recommendation: Weak

OXFORD

BJS, 2022, 1–12
https://doi.org/10.1093/bjs/znac302
Guideline

Updated guideline for closure of abdominal wall incisions from the European and American Hernia Societies



And yet……

Hernia prevention: practice patterns and surgeons' attitudes about abdominal wall closure and the use of prophylactic mesh

J. P. Fischer[1] · H. W. Harris[2] · M. López-Cano[3] · W. W. Hope[4] Hernia (2019) 23:329–334

Table 2 Questions and responses regarding knowledge and practice patterns for laparotomy closure

Question	Response	Percentage
(1) How many primary laparotomy or abdominal wall closures do you perform yearly?	< 15	12.45
	16–50	36.35
	51–100	26.51
	> 100	24.7
(2) Which of the following describes your usual technique for laparotomy/abdominal wall closure?	Running permanent suture (ex: Prolene)	9.07
	Running fast absorbing suture (ex: Vicryl)	2.62
	Running slowly absorbing suture (ex: PDS)	80.85
	Interrupted permanent suture (ex: Prolene)	1.21
	Interrupted fast absorbing suture (ex: Vicryl)	2.42
	Interrupted slowly absorbing suture (ex: PDS)	2.22
	Other	1.61
(3) Which of the following best describes your knowledge of the 4:1 suture-to-wound length ratio for laparotomy closure?	Never heard of it	4.26
	Familiar with it, but do not practice	15.21
	Practice but do not measure my suture-to-wound length ratio	63.08
	Practice and measure my suture-to-wound length ratio	15.62
	Other	1.83
(4) Which of the following best describes your knowledge and practice using the short stitch (small bites) laparotomy closure?	Never heard of it	3.04
	Familiar with it, but do not practice	23.33
	Practice but do not measure my suture-to-wound length ratio and number of sutures placed	58.01
	Practice and measure my suture-to-wound length ratio and number of sutures placed	13.79
	Other	1.83
(5) If you are aware of short stitch (small bites) laparotomy closure methods but do not practice it, which of the following best describes your reason for this?	Does not apply to my patient population	18.83
	I am not familiar enough with the methods to correctly perform it	24.27
	It takes too long	12.97
	I am not reimbursed for performing it	3.77
	I am concerned about the possibility of a closure-related complication	26.78
	Other	22.18

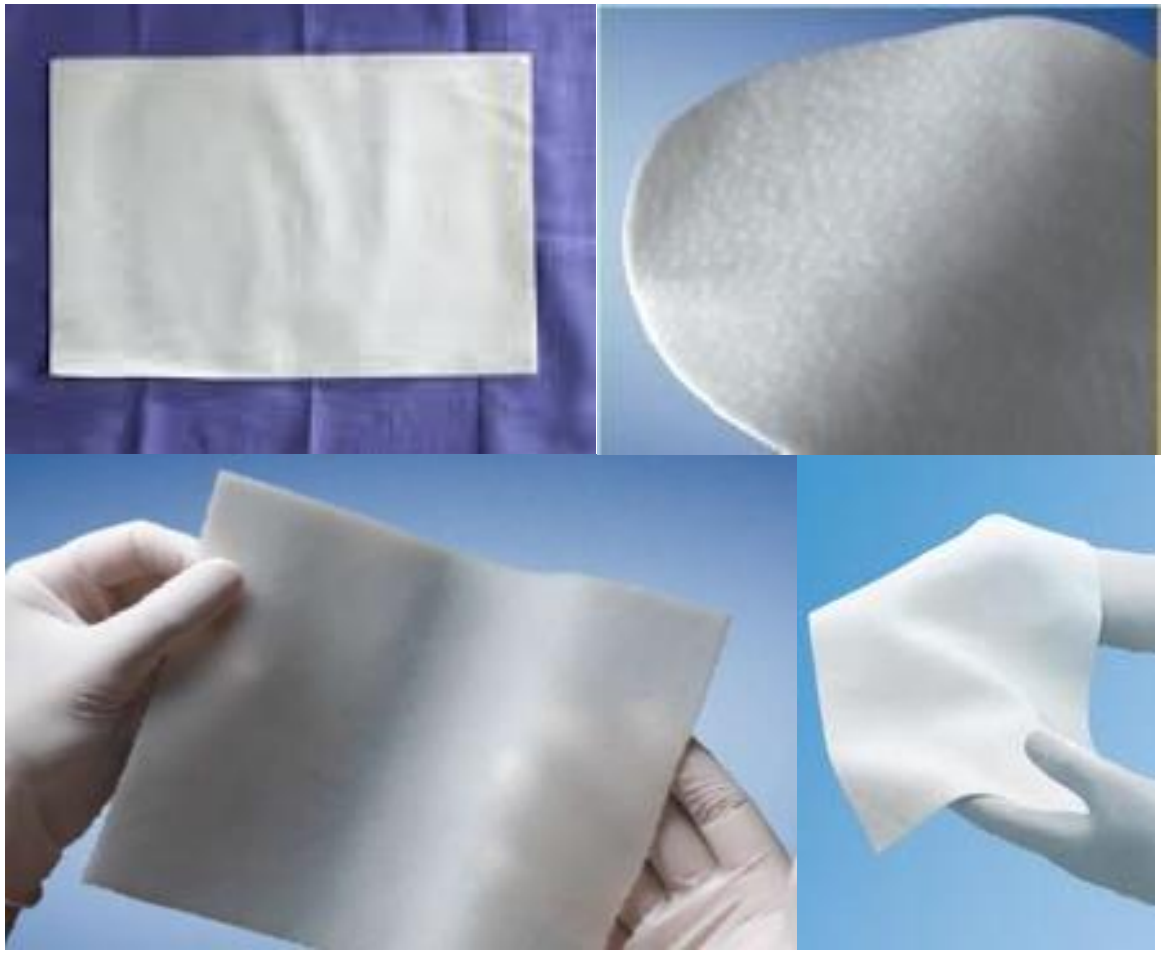
Table 3 Questions and responses related to knowledge and practice patterns regarding the use prophylactic mesh

Question	Response	Percentage
(1) I understand that the incisional hernia incidence at 5 years following laparotomy is	5%	4.02
	10%	15.29
	15%	22.74
	20%	40.04
	30%	14.49
	Other	3.42
(2) Which best describes your knowledge/interest in prophylactic mesh for hernia prevention in laparotomy closure for high risk patients?	Not familiar with literature	11.11
	Familiar with literature but would not use	24.04
	Familiar with literature and interested in using	45.05
	Familiar with literature and already doing	15.35
	Other	4.44
(3) If you are familiar with, but do not perform prophylactic mesh placement for hernia prevention, which of the following best describes your reason for this?	Does not apply to my patient population	12.56
	I am not familiar enough with the methods to correctly perform it	12.31
	It takes too long	6.41
	I am not reimbursed for performing it	14.36
	Not convinced of benefit	23.08
	I am concerned about the possibility of mesh infection or mesh-related complications	46.9
	Other	13.59
(4) If you are familiar with and perform prophylactic mesh placement for hernia prevention, in which position do you place the mesh?	Onlay	25.54
	Sublay	50.65
	Intraperitoneal	8.23
	Other	15.58
(5) If you are familiar with and perform prophylactic mesh placement for hernia prevention, which kind of mesh do you use?	Permanent synthetic	63.52
	Absorbable synthetic	16.74
	Biologic	4.72
	Other	15.02

Surgeons (and patients) want an alternative

BIOLOGIC MESHES

- Heterogenous group Xenografts
  - Dermis — Bovine
  - Pericardium — Porcine
  - SIS — Ovine
- Processing alters performance
  - *in vivo & in vitro*
  - Tensiometrics
  - Immunological behaviour
  - Remodelling



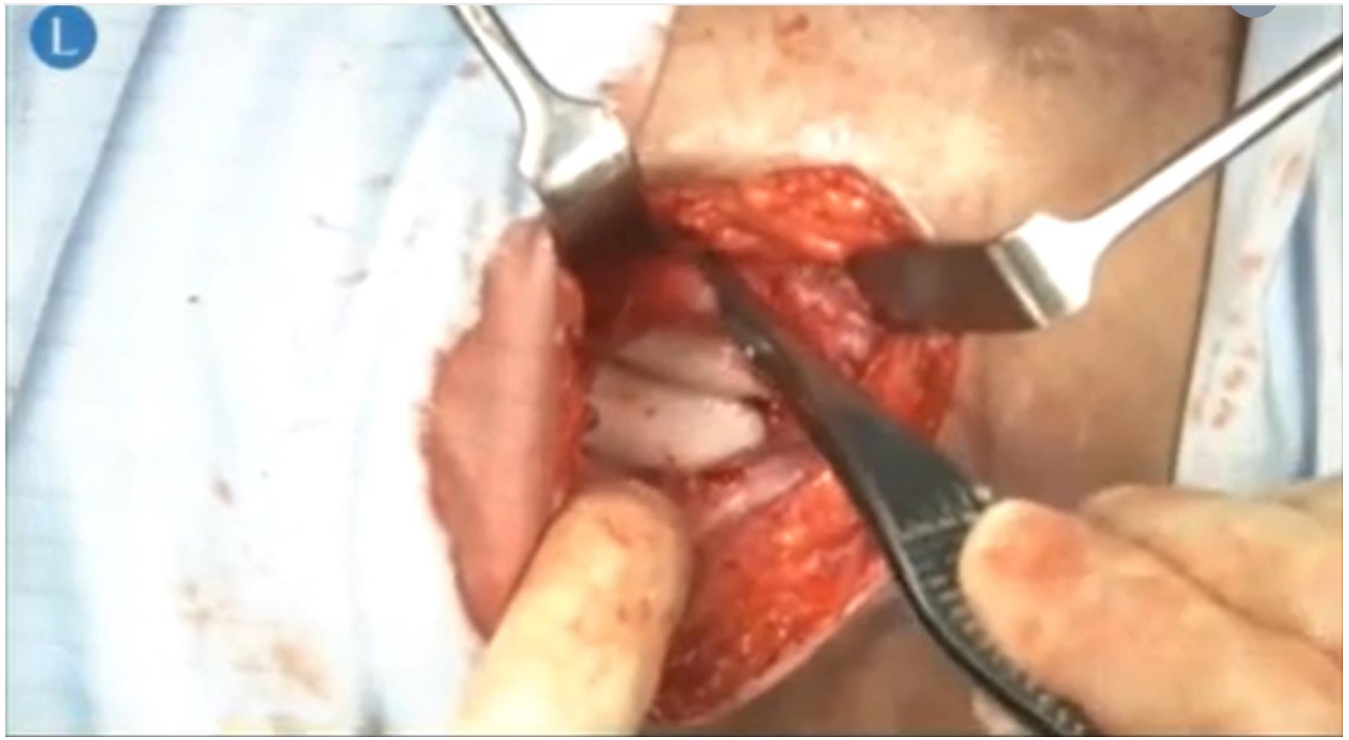
ROCSS

Feasibility study from a randomized controlled trial of standard closure of a stoma site *vs* biological mesh reinforcement

On behalf of the Reinforcement of Closure of Stoma Site (ROCSS) Collaborative and the West Midlands Research Collaborative[1]

Colorectal Disease © 2016 The Association of Coloproctology of Great Britain and Ireland. **18,** 889–896

- Intra-peritoneal biologic mesh
- Colorectal surgeons not hernia specific surgeons
- Training & quality assurance

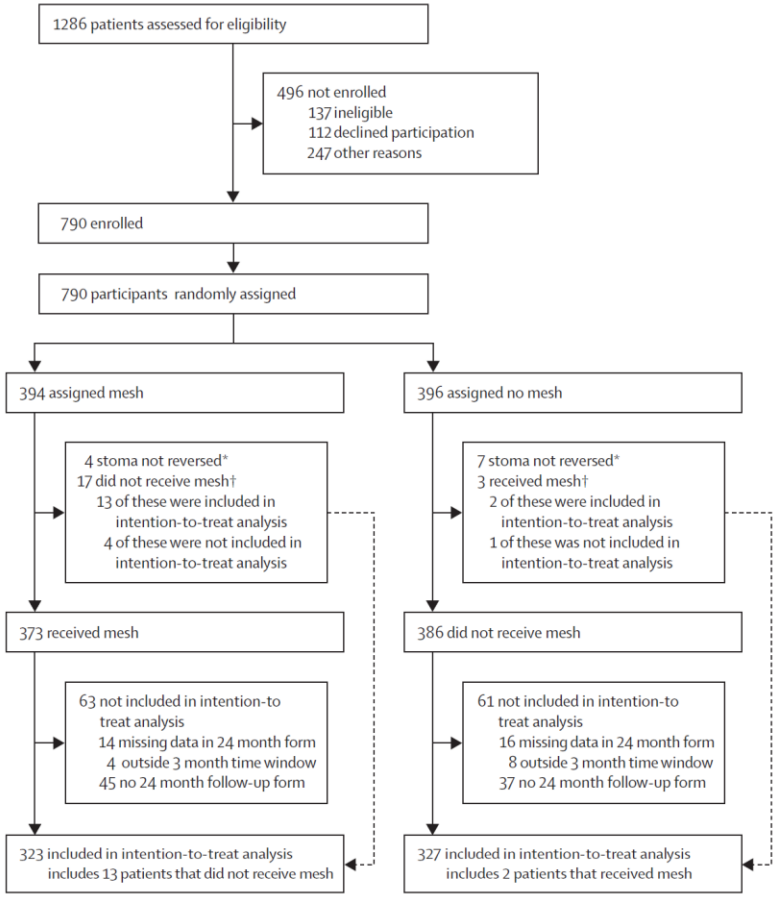


ROCSS

Prophylactic biological mesh reinforcement versus standard closure of stoma site (ROCSS): a multicentre, randomised controlled trial

Lancet 2020; 395: 417–26

*Reinforcement of Closure of Stoma Site (ROCSS) Collaborative and West Midlands Research Collaborative**



	Mesh (n=394)	Control (n=396)	Total (n=790)
Age, years			
Mean	58·4 (16·0)	59·0 (16·0)	58·7 (16·0)
Range	18·0–89·0	19·0–89·0	18·0–89·0
Sex			
Male	263 (67%)	251 (63%)	514 (65%)
Female	131 (33%)	145 (37%)	276 (35%)
Body-mass index			
Mean	26·8 (4·8)	26·6 (5·2)	26·7 (5·0)
Diabetes			
No	351 (89%)	357 (90%)	708 (90%)
Yes	42 (11%)	37 (9%)	79 (10%)
Missing	1 (<1%)	2 (<1%)	3 (<1%)
Steroid medications			
No	377 (96%)	382 (97%)	759 (96%)
Yes	15 (4%)	12 (3·0%)	27 (3%)
Missing	2 (<1%)	2 (<1%)	4 (<1%)
Original indication for stoma?			
Cancer	227 (58%)	217 (55%)	444 (56%)
Non-cancer	167 (42%)	179 (45%)	346 (44%)
Type of stoma opening			
Loop	295 (75%)	310 (78%)	605 (77%)
End	99 (25%)	86 (22%)	185 (23%)
Type of stoma being closed*			
Ileostomy	315 (80%)	316 (80%)	631 (80%)
Colostomy	79 (20%)	80 (20%)	159 (20%)
Side of stoma			
Right side	307 (78%)	306 (77%)	613 (78%)
Left side	87 (22%)	90 (23%)	177 (22%)
Parastomal hernia evident			
No	284 (72%)	301 (76%)	585 (74%)
Yes	110 (28%)	95 (24%)	205 (26%)
Midline incisional hernia evident			
No	372 (94%)	380 (96%)	752 (95%)
Yes	22 (6%)	16 (4%)	38 (5%)
Midline laparotomy planned*			
No	339 (86%)	341 (86%)	680 (86%)
Yes	55 (14%)	55 (14%)	110 (14%)
Planned skin closure*			
Primary	274 (70%)	274 (69%)	548 (70%)
Secondary	120 (30%)	120 (30%)	240 (30%)
Missing	0	2 (1%)	2 (<1%)

Data are mean (SD) or n (%). *Minimisation variables.

Table 1: **Baseline characteristics**

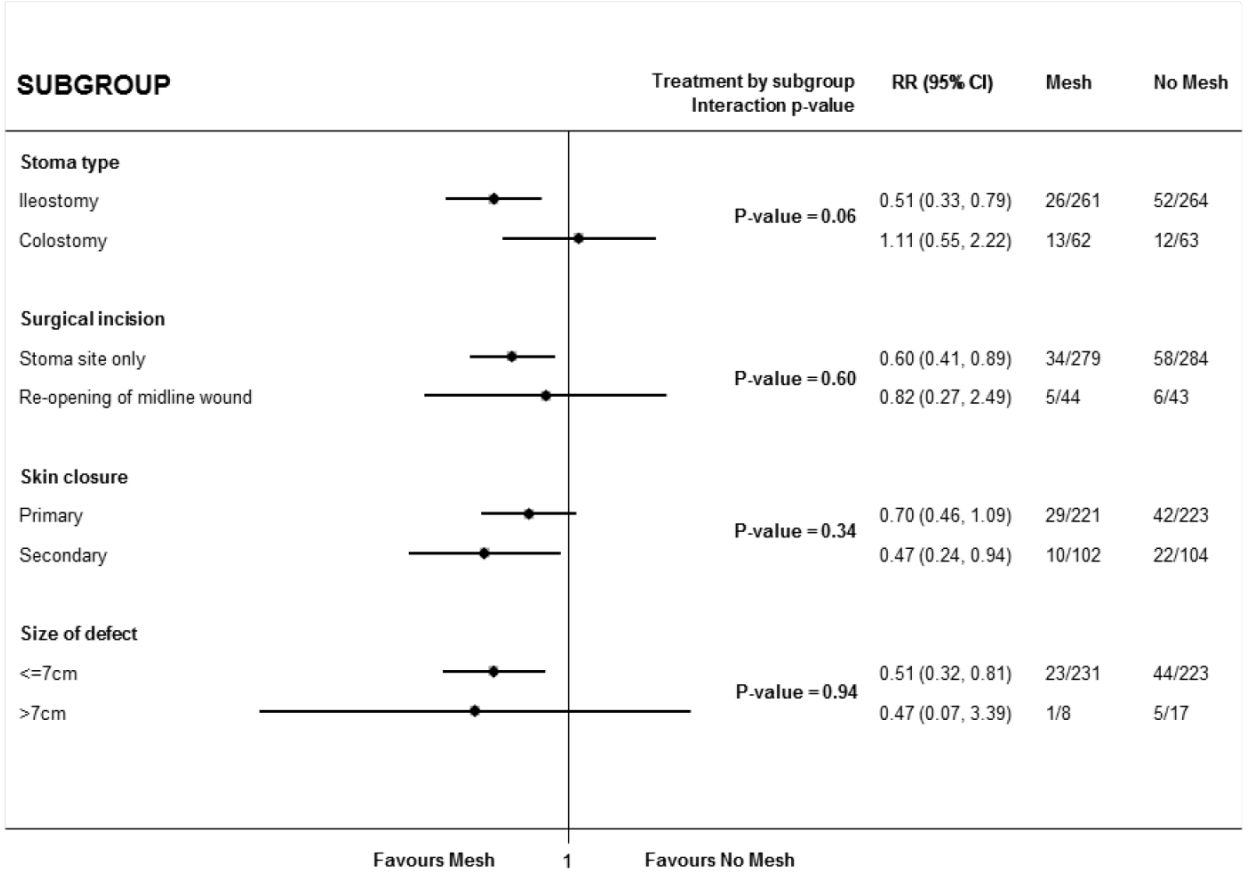
	Mesh (n=394)	Control (n=396)	Total (n=790)
Number of intraoperative forms available	393	396	789
Duration of surgery (to nearest 10 min)	90 (70–130)	70 (50–100)	80 (60–120)
Surgical access			
Non-midline	326 (83%)	337 (85%)	663 (84%)
Midline	66 (17%)	58 (15%)	124 (16%)
Missing	1 (<1%)	1 (<1%)	2 (<1%)
Evidence of midline hernia			
No	342 (87%)	351 (89%)	693 (88%)
Yes	32 (8%)	25 (6%)	57 (7%)*
Suture repair	13	13	26
Mesh repair†	2	1	3
Missing	19 (5%)	20 (5%)	39 (5%)
Evidence of parastomal hernia			
No	233 (59%)	231 (58%)	464 (59%)
Yes	142 (36%)	151 (38%)	293 (37%)
Missing	18 (5%)	14 (4%)	32 (4%)
Size of fascial defect			
≤7 cm	274 (70%)	265 (67%)	539 (68%)
>7 cm	11 (3%)	20 (5%)	31 (4%)
Missing	108 (27%)	111 (28%)	219 (28%)‡
Skin closure			
Fully closed	200 (51%)	192 (49%)	392 (50%)
Left partially or completely open	192 (49%)	199 (50%)	391 (49%)
Missing	1 (<1%)	5 (1%)	6 (1%)

BIOLOGIC MESH WORKS

	Mesh	Control	Adjusted relative risk* (95% CI)	p value
Primary outcome				
Clinical hernia at 2 years	39/323 (12%)	64/327 (20%)	0·62 (0·43–0·90)	0·012
Secondary outcome at 30 days				
Wound infection	60/371 (16%)	49/369 (13%)	1·19 (0·84–1·68)	0·32
Secondary outcomes at 12 months				
Radiological hernia	20/229 (9%)	47/226 (21%)	0·42 (0·26–0·69)	<0·001
Symptomatic hernia	27/316 (9%)	36/315 (11%)	0·75 (0·47–1·21)	0·24
Wound infection	63/364 (17%)	53/362 (15%)	1·16 (0·83–1·60)	0·39
Seroma formation	10/353 (3%)	8/355 (2%)	1·26 (0·51–3·14)	0·61
Secondary outcomes at 24 months				
Symptomatic hernia	52/329 (16%)	64/331 (19%)	0·83 (0·60–1·16)	0·29
Surgical re-intervention at stoma site	42/344 (12%)	54/346 (16%)	0·78 (0·54–1·13)	0·19

Data are n/N (%) unless otherwise specified. *Adjusted for minimisation variables (midline laparotomy planned; planned skin closure; type of stoma being closed). An adjusted relative risk value of less than 1 favours mesh.

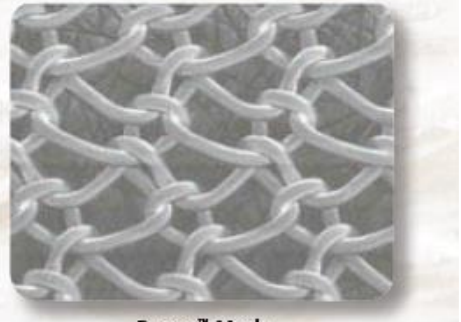
Table 3: **Primary and secondary outcomes**

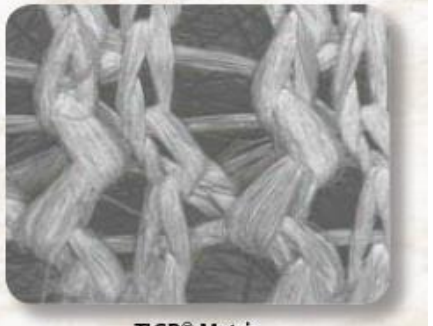


Delayed absorbable “biosynthetic” meshes

Table 1. Preclinical Data on Long-Acting Resorbable Mesh

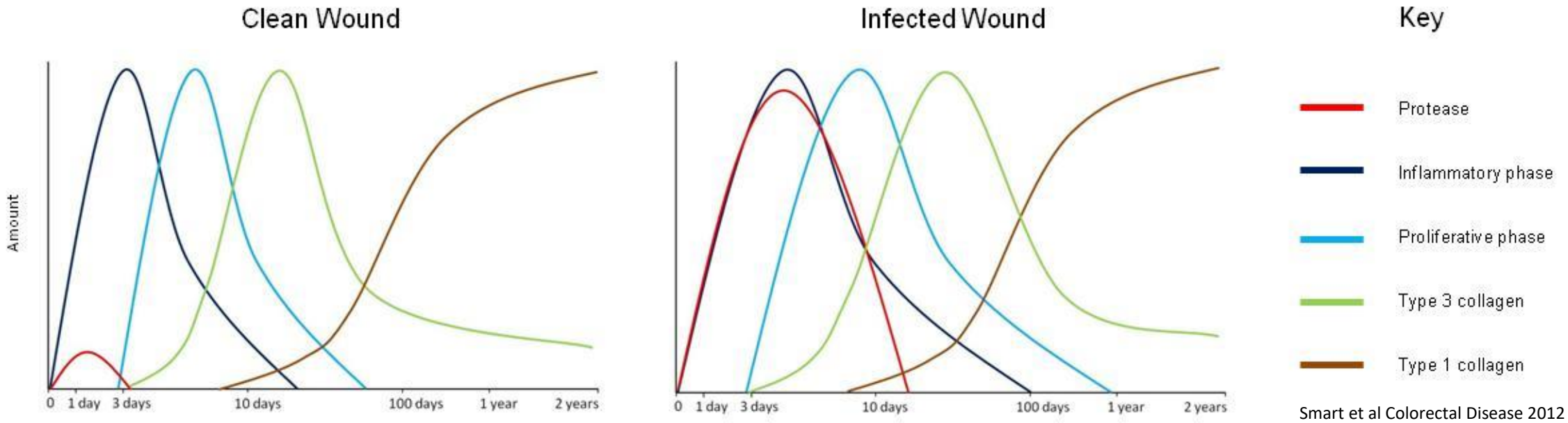
	Resorption Time (mo)	Residual Strength	Histology	Collagen
TM	36	> 50% @ 6 mo; < 50% @ 9 mo	Less inflammation than PP @ 36 mo	Total and type I/III collagen greater than PP
Gore Bio-A	6	< 50% @ 3–4 mo	Greater cellular/vascular ingrowth at 14 d compared with biologics	All type I
Phasix	12–18	< 50% @ 4–8 mo	Mild/moderate inflammation and granulation	Type I/III collagen ratio increases from 6–52 wk


PHASIX™ Mesh
SEM photo, 20x


TIGR® Matrix
SEM photo, 20x


Bio-A® Tissue Reinforcement
SEM photo, 20x

Delayed absorbable “biosynthetic” meshes



Smart et al Colorectal Disease 2012

Polyglactin 910

Bioabsorbable mesh

Polyglactin 910

Bioabsorbable mesh

Are “biosynthetic” meshes the answer?

Safety and efficacy of prophylactic resorbable biosynthetic mesh following midline laparotomy in clean/contemned field: preliminary results of a randomized double blind prospective trial

Hernia (2020) 24:85–92

F. Pizza[1] · D. D’Antonio[1] · M. Arcopinto[2] · C. Dell’Isola[3] · A. Marvaso[1]

	Group A ($n=50$)	Group B ($n=50$)	p
Sex, male–female (%)	36–62 (48%)	41–59 (52%)	>0.05
Age, mean (range), years	56 (22–86)	58 (29–88)	>0.05
BMI, mean (range), kg/m^2	27 (18–38)	28 (17–35)	>0.05
Active smoking, n (%)	11 (22%)	13 (26%)	>0.05
Diabetes, n (%)	9 (18%)	8 (16%)	>0.05
Cardiac disease, n (%)	11 (22%)	13 (26%)	>0.05
COPD, n (%)	11 (22%)	15 (30%)	>0.05
Previous radiotherapy or chemotherapy, n (%)	3 (6%)	2 (4%)	>0.05
Previous abdominal operations, n (%)	2 (4%)	8 (16%)	>0.05
Other abdominal hernias, n (%)	4(8%)	2 (4%)	>0.05
CCS chronic use, n (%)	2 (4%)	1 (2%)	>0.05
Length of laparotomy, mean (range) cm	26 (18–27)	25 (20–29)	>0.05

	Group A	Group B	p
Clean-contaminated wound (CDC class II), n (%)	30 (60)	28 (56)	$p>0.05$
Contaminated wound (CDC class III), n (%)	20 (40)	22 (44)	$p>0.05$
Length of laparotomy, mean (range), cm	26 (18–27)	25 (20–29)	$p>0.05$
Operation time (for abdominal wall closure), mean (range), min	14 (8–18)	22 (14–27)	$p>0.05$
Emergency surgery, n (%)	22 (44)	31 (62)	$p<0.05$

Table 3 Incidence of incisional hernia (IH) at 6, 12 and 24 months follow-up, found either by clinical exam or ultrasounds (US)

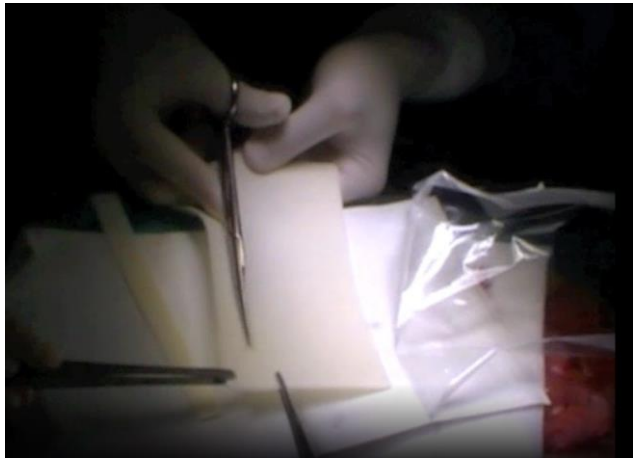
	Group A	Group B	p
IH (6 months), n (%)	6/50 (12%)	1/50 (2%)	$p<0.05$
IH (12 months), n (%)	10/49 (20%)	3/48 (6%)	$p<0.05$
IH (24 months), n (%)	11/47 (22%)	3/45 (6%)	$p<0.05$

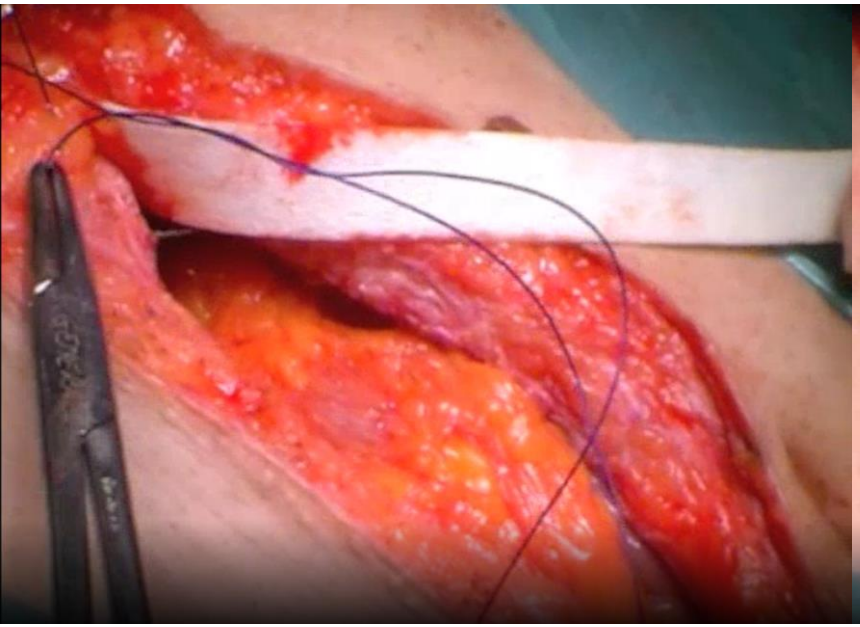
Biosynthetic prophylaxis RCT

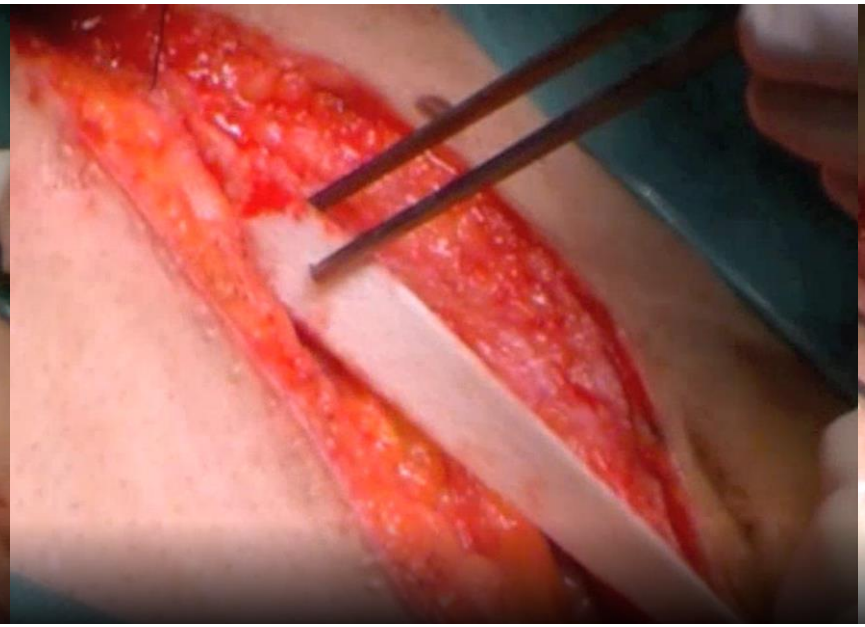
PREBIOUS trial: A multicenter randomized controlled trial of PREventive midline laparotomy closure with a BIOabsorbable mesh for the prevention of incisional hernia: Rationale and design

Manuel López-Cano [a,g,*], José A. Pereira [b], Roberto Lozoya [c], Xavier Feliu [d], Rafael Villalobos [e], Salvador Navarro [f], Maria Antonia Arbós [g], Manuel Armengol-Carrasco [a,g]

Contemporary Clinical Trials 39 (2014) 335–341





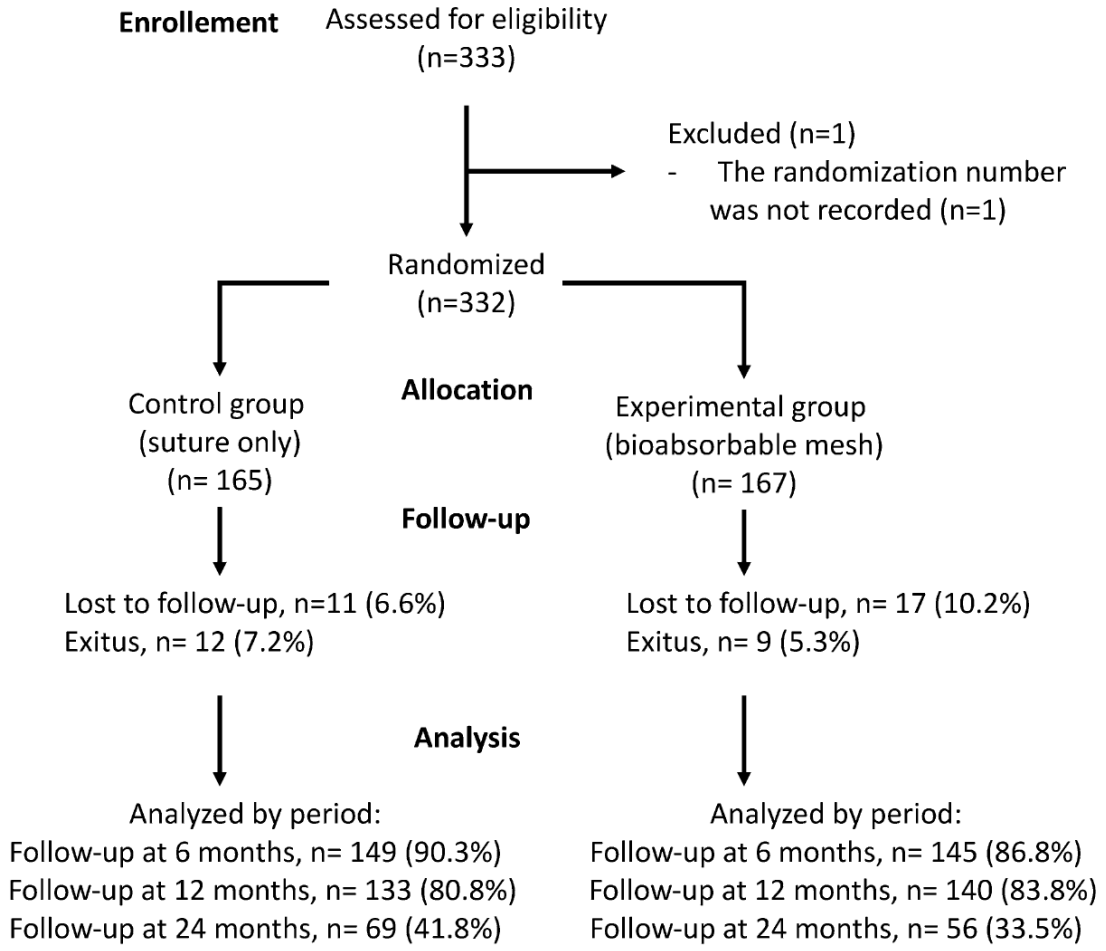


Biosynthetic prophylaxis RCT

Use of a bioabsorbable mesh in midline laparotomy closure to prevent incisional hernia: randomized controlled trial

Hernia
https://doi.org/10.1007/s10029-021-02435-3

S. Valverde[1] · M. A. Arbós[2] · M. T. Quiles[2] · E. Espín[2,3] · J. L. Sánchez-Garcia[2,3] · V. Rodrigues[1,2] · J. A. Pereira[4] · R. Villalobos[5] · J. M. García-Alamino[6,7] · M. Armengol[1,2] · M. López-Cano[1,2]



Variables	Study groups	
	Control (suture only) (No = 165)	Experimental (mesh) (No = 167)
Age, years, mean (SD)	64.3 (15.6)	66.4 (16.9)
Sex (Male/female)	99/66	96/71
Body mass index, kg/m^2, mean (SD)	26.9 (5.8)	26.7 (5.0)
Type of surgery		
Clean	8 (4.8)	11 (6.6)
Clean/contaminated	111 (67.3)	94 (56.3)
Contaminated	42 (25.5)	45 (26.9)
Dirty	4 (2.4)	17 (10.2)
Intraoperative antibiotics	164 (99.4)	164 (98.2)
Midline incision length, cm (SD)	18.2 (5.9)	19.1(6.6)
Suture length, cm, mean (SD)[a]	78.5 (30.0)	85.6 (31.5)
SL:WL ratio (SD)	4.4:1 (1.1)	4.6:1 (1.2)
Closing time, min, mean (SD)	23.8 (9.6)	25.3 (10.8)

Biosynthetic prophylaxis RCT

Use of a bioabsorbable mesh in midline laparotomy closure to prevent incisional hernia: randomized controlled trial

Hernia
https://doi.org/10.1007/s10029-021-02435-3

S. Valverde[1] · M. A. Arbós[2] · M. T. Quiles[2] · E. Espín[2,3] · J. L. Sánchez-Garcia[2,3] · V. Rodrigues[1,2] · J. A. Pereira[4] · R. Villalobos[5] · J. M. García-Alamino[6,7] · M. Armengol[1,2] · M. López-Cano[1,2]

Table 3 Incidence of Incisional Hernia (IH) detected by CT examination at follow-up in the two study groups

Follow-up period	Study groups						Statistical significance[a] Relative risk (95% CI)	NNT
	Control (suture only)			Experimental (mesh)				
	Total patients	IH No. (%)	No IH No. (%)	Total patients	IH No. (%)	No IH No. (%)		
6 months	149	37 (24.8)	112 (75.2)	145	22 (15.2)	123 (84.8)	0.66 (0.38–0.98) $P=0.042$	11
12 months	133	44 (33.1)	89 (66.9)	140	30 (21.4)	110 (78.6)	0.64 (0.43–0.96) $P=0.033$	9
24 months	69	47 (68.1)	22 (31.9)	56	33 (59.0)	23 (41.0)	0.86 (0.65–1.13) $P=0.296$	-

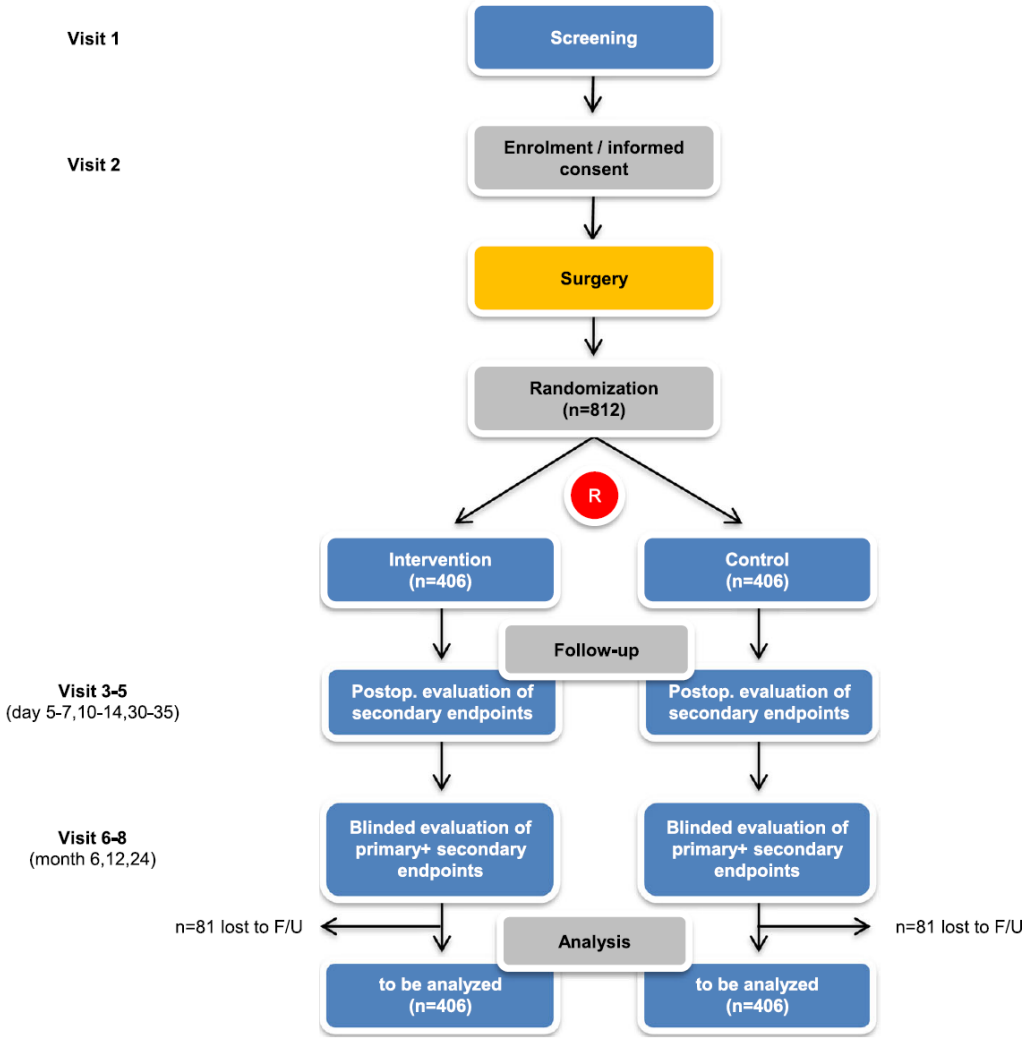
- No data on:
  - Hernia size / EHS classification
  - Symptoms
  - Need for repair

Hernia reduction following laparotomy using small stitch abdominal wall closure with and without mesh augmentation (the HULC trial): study protocol for a randomized controlled trial

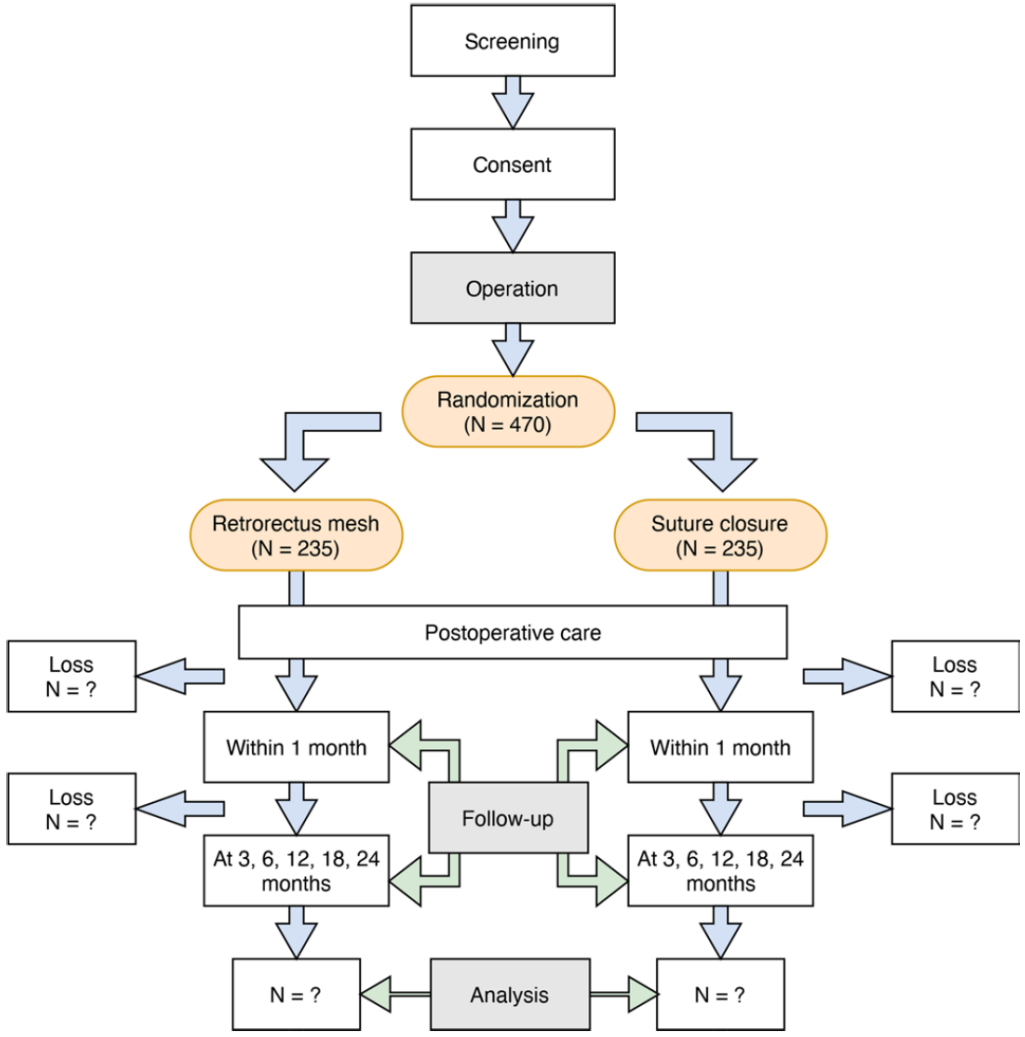
Small bite & mesh RCTs

Midline incisional hernia prophylaxis using synthetic mesh in an emergency or urgent gastrointestinal tract surgery: a protocol for multicentre randomised clinical trial

Heger *et al. Trials* (2019) 20:738



Tansawet A, *et al. BMJ Open* 2021;**11**:e045541.



Hernia prevention in colorectal surgery

- Significant clinical problem that is difficult to treat
- Evolving surgical armamentarium for prevention
- Multiple meshes & techniques now evaluated – more to come
- Colorectal surgeons need to own the problem – prophylaxis is ***OUR*** business