RISK FACTORS ASSOCIATED TO INCISIONAL HERNIA IN STOMA SITE AFTER STOMA CLOSURE: A SYSTEMATIC REVIEW AND META ANALYSIS

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UNIVERSIDAD DEL ROSARIO
PROJECT PRESENTED TO OBTAIN THE
GENERAL SURGEON DEGREE

BOGOTÁ, COLOMBIA
2023

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SCHOOL OF MEDICINE
GENERAL SURGERY
UNIVERSIDAD DEL ROSARIO

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2023

IDENTIFICATION

INSTITUTION: UNIVERSIDAD DEL ROSARIO

PROGRAM: GENERAL SURGERY

TITLE: RISK FACTORS ASSOCIATED TO INCISIONAL HERNIA IN STOMA SITE AFTER STOMA CLOSURE: A SYSTEMATIC REVIEW AND META ANALYSIS

PARTICIPATING INSTITUTIONS: HOSPITAL UNIVERSITARIO MAYOR - MEDERI

TYPE OF INVESTIGATION: META-ANALYSIS

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Risk factors associated to incisional hernia in stoma site after stoma closure: A systematic review and meta-analysis

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Content

Abstract

Purpose: This study aims to identify which risk factors are associated to the appearance of an incisional hernia in a stoma site after its closure. This in the sake of identifying which patients would benefit from a preventative intervention and thus start implementing a cost-effective protocol for prophylactic mesh placement in high-risk patients.

Methods: A systematic review of PubMed, Cochrane library and ScienceDirect was performed according to PRISMA guidelines. Studies reporting incidence, risk factors and follow-up time for appearance of incisional hernia after stoma site closure were included. A fixed-effects and random effects models were used to calculate odds ratios' estimates and standardized mean values with their respective grouped 95% confidence interval. This to evaluate the association between possible risk factors and the appearance of incisional hernia after stoma site closure.

Results: 17 studies totaling 2899 patients were included. Incidence proportion between included studies was of 17,78% (CI95%: 13,51 – 22,50%). Out of the evaluated factors obesity (p<0,001, index (p<0,001, Cohen's d=0.63, SE=011), presence of parastomal hernia (p=0,001, LogOR=1.24, SE=0.38), colostomy (p=0,001 LogOR=-0.71, SE=0.15) and end stoma (p=0,040, LogOR=-0,38, SE=-0,18) were associated to the appearance of incisional hernia in stoma site after stoma closure.

Conclusions: Prophylactic mesh placement should be considered as an effective preventative intervention in high-risk patients (obese patients, patients with parastomal hernia, colostomy and end stoma patients) with the goal of reducing incisional hernia rates in stoma site after closure while remaining cost-effective.

Keywords: Incisional hernia, stoma closure, stoma reversal, risk factors, prevention.

Declarations

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or nonprofit sectors.

Conflicts of interest: All authors declare no conflicts of interest.

Author contribution

Camilo Ramírez-Giraldo: Study conception and design, acquisition of data, data analysis and interpretation, drafting of manuscript, critical revision of manuscript.
Isabella Van-Londoño: Data analysis and interpretation, drafting of manuscript, critical revision of manuscript.
Danny Conde Monroy: Analysis and interpretation of data, drafting of manuscript, critical revision of manuscript.
Jorge Navarro-Alean: Study conception and design, data acquisition, critical revision of manuscript.
Juliana Hernández-Ferreira: Study conception and design, data acquisition, critical revision of manuscript.
Daniela Hernández-Álvarez: Study conception and design, data acquisition, critical revision of manuscript.
Susana Rojas Lopez: Drafting of manuscript, critical revision of manuscript.

Registration of research studies

Available on PROSPERO (ID: CRD42023397394).

Introduction

Stomas are widely used in current surgical practice for both urgent and scheduled procedures, mostly to avoid complications associated with healing of the anastomosis after colorectal surgery (1). However, stoma closure procedures are also at risk of complications like incisional hernias, which have a variable incidence depending on the different studies available, oscillating between 0-48% with a presentation median of 7%. This variability can be explained by the method of diagnosis (physical examination vs diagnostic imaging) and follow-up time (2–4).

The use of a prophylactic mesh reduces the probability of presenting an incisional hernia in stoma site after its closure, with an increase in surgical time but without differences in surgical site infection, seroma and anastomosis leak rates (5,6).

Incisional hernia appearance represent high costs to the health care system and thus effective preventative measures are important (7); a recent analysis on prophylactic mesh placement during stoma closure found the intervention to be inefficient cost-wise, however, this could prove cost-effective if prophylactic mesh placement was performed exclusively on high-risk patients or if more affordable materials are used (8). There has been a peak on the use of prophylactic meshes due to their benefits in preventing incisional hernias and their subsequent correction, both of which represent additional costs and complications to the patient and healthcare system (9). Another important aspect to take into account is the patient's perspective regarding prophylactic mesh placement, in which the patient could be more open to the possibility if the attending team explains the risk-benefit of the procedure considering the patient's risk factors versus when it is offered to all patients regardless of their individual conditions (10).

Different studies have already described multiple risk factors for appearance of an incisional hernia in the stoma site after its closure such as male gender, arterial hypertension, diabetes mellitus, higher BMI, type of stoma, parastomal hernia, amongst others (11,12). However, the evidence on most of these factors is nonconclusive and controversial. Considering the previously stated, this study aims to identify which risk factors are associated with incisional hernia appearance in stoma site after its closure to identify which patients would most benefit on prophylactic mesh placement in the stoma site as a preventative measure and thus be able to implement this intervention into a protocol that is both beneficial and cost-effective.

Conceptual framework

In today's surgical practice, stomas are frequently utilized for both urgent and planned treatments, primarily to prevent major anastomotic complications (1). However, after stoma closure, due to the abdominal wall gap (frequently greater than 2 centimeters), there is a risk for the development of incisional hernias. The incidence of incisional hernias after the closure of temporary ostomies is up to 7.4 - 40% (1, 11) within a median follow-up of 36 months, depending on the risk bias included in every study. Nonetheless, there are no data known to characterize the long-term risk, and also the efficiency of examination versus clinical imaging is lower;

therefore, studies based solely on clinical examination may underestimate the prevalence of the problem. Additionally, the morbidity of this complication includes several difficult-to-treat symptoms such as chronic pain, impaired quality of life, inability to work, as well as psychological symptoms such as altered body image and depression. In addition to surgical emergencies due to bowel obstruction (6 - 15%) and strangulation (2%) (1).

We found in current literature there are some risks factors documented to be related to the development of the abdominal wall defect after closure, most of these risk factors end up acting by either increasing surgical site infection, wound dehiscence or by delaying normal wound healing process. Some are intrinsically related to the patient such as age and male gender, some other are related to comorbidities on the patient such as chronic obstructive pulmonary disease, diabetes, hypertension, malnutrition, immunosuppression, glucocorticosteroid use, oral anticoagulants, connective tissue disorders, jaundice, respiratory disorders, know malignancy and cachexia, and there are also lifestyle risk factors such as smoking obesity. There are also surgical related risk factors such as emergency surgery, contaminated surgery, abdominal distension, reoperation, postoperative respiratory failure, suture choice and closing technique that can be related to the development of this hernias (11). These hernias could frequently appear within 2 years after stoma closure (1).

Incisional hernia represents high costs to the health care system and can affect patients in productive ages. Thus, effective preventive measures are important. Complications arising from incisional hernias after closing any stoma can be therefore associated with significant financial burden on health care systems (to repair incisional hernia after stoma closure has been estimated at $16000 by procedure in the US).

We also reviewed the preventive measures to prevent the appearance of hernias, such as the use of a small length suture to diminish wall tension and the kind of mesh used to correct the defect; nonetheless, there was no significant statistical difference. However, the use of a prophylactic mesh reduces the probability of presenting an incisional hernia in the stoma site after its closure, with an increase in surgical time but without differences in surgical site infection, seroma, and anastomosis leak rates (5, 6)

A recent analysis on prophylactic mesh placement during stoma closure found the intervention to be inefficient cost-wise; however, this could prove cost-effective if prophylactic mesh placement was performed exclusively on high-risk patients or if more affordable materials are used (8). There has been a peak in the use of prophylactic meshes due to their benefits in preventing incisional hernias and their subsequent correction, both of which represent additional costs and complications to the patient and healthcare system (9).

Materials and methods

A systematic review and meta-analysis was performed following the “Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA)” guidelines (12,13). The study protocol is registered on PROSPERO.

Search strategy

Two independent reviewers (C.R and D.C.) performed a systematic review of the literature to identify eligible articles. PubMed, Cochrane and ScienceDirect databases were searched using the following search terms: "stoma closure" AND "hernia" OR "stoma" AND "incisional hernia" OR "ostomy AND incisional hernia" OR “stoma reversal AND hernia” with no time limit. References from the included articles will be reviewed on eligible documents. Both English and Spanish language studies were considered.

Study selection and data extraction

Eligible studies were included if they met the following inclusion criteria: (i) studies that involved human subjects for which the complete article was available; (ii) studies on patients on which stoma closure was performed; (iii) studies that reported incidence, risk factors and follow-up time for incisional hernia in stoma site after closure. Both observational prospective and retrospective studies were included. Studies that had insufficient data on results and patient characteristics, that included patients younger than 18 years, that used prophylactic mesh after stoma closure, studies with a mean or average follow-up time shorter than 12 months, and studies that included less than 10 patients were excluded.

Two authors (C.R. and D.C.) selected studies independently through a selection of titles and abstracts, duplicate articles present in different databases were promptly identified and discarded. Afterwards, both authors exchanged their lists on the articles found in their searches to compare lists with an emphasis on consensus. If any contradictions appeared between reviewers, a third reviewer (I.V.) intervened to establish consensus. Finally, one of the researchers (C.R.) extracted relevant data from the found articles and input them manually in a Microsoft Excel ® version 16.6 database. Two reviewers (C.R. and D.C) independently performed a quality assessment on the found articles using the quality assessment scale MINORS. Ultimately, their results were compared and a third reviewer (I.V) was involved to reach consensus when necessary (14).

The following risk factors were evaluated: age, gender, body mass index (BMI), comorbidities (arterial hypertension, diabetes mellitus, chronic obstructive pulmonary disease (COPD), tobacco use, presence of malignant disease, neoadjuvant therapy, adjuvant therapy), procedure indication (e.g. stoma protection after primary anastomosis, stomas created in an emergency after an anastomotic leak) , index procedure, abdominal wall closure technique, stoma characteristics (colostomy or ileostomy, loop or end), complications associated with the stoma (parastomal hernia or prolapsed stoma), surgical approach (localized, laparotomy or laparoscopy) and time elapsed from stoma procedure to its closure.

Data synthesis and quality assessment

The incidence of patients presenting with incisional hernia was calculated. In the case of categorical variables the association between the possible risk factors and appearance of incisional hernia in stoma site after its closure was calculated with the effect size (ES) using the odds ratio (OR) logarithm and the respective standard error of estimate with its respective confidence interval (CI95%) for dicotomic outcomes. Continuous variables were analyzed using the mean difference (Cohen's d) and were estimated using a random-effects model based on the Der Simonian and Laird method (16).To further illustrate the results of this meta-analysis different forest plots were generated. Publication bias was assessed using the Eggers' test and were graphed as a funnel plot. Heterogeneity between studies was evaluated with Cochran's Q test and/or Higgins test (I^2 statistic to measure the grade of variation non-attributable to chance alone). Heterogeneity was then classified as low ($I^2 < 25$ %), moderate ($I^2 = 25$ % to 75 %) or high ($I^2 > 75$ %). All models were performed using random effects due to the

clinical and methodological heterogeneity presented in the included studies. Sensitivity analyses were performed to determine the robustness of the results **(supplement 1)**. The statistical analysis was performed using the R version 4.3.0 in the Environment RStudio 2023.03.1, with the package meta (General Package for Meta-Analysis) version 6.2-1 (17). A p value of <0.05 was considered as statistically significant.

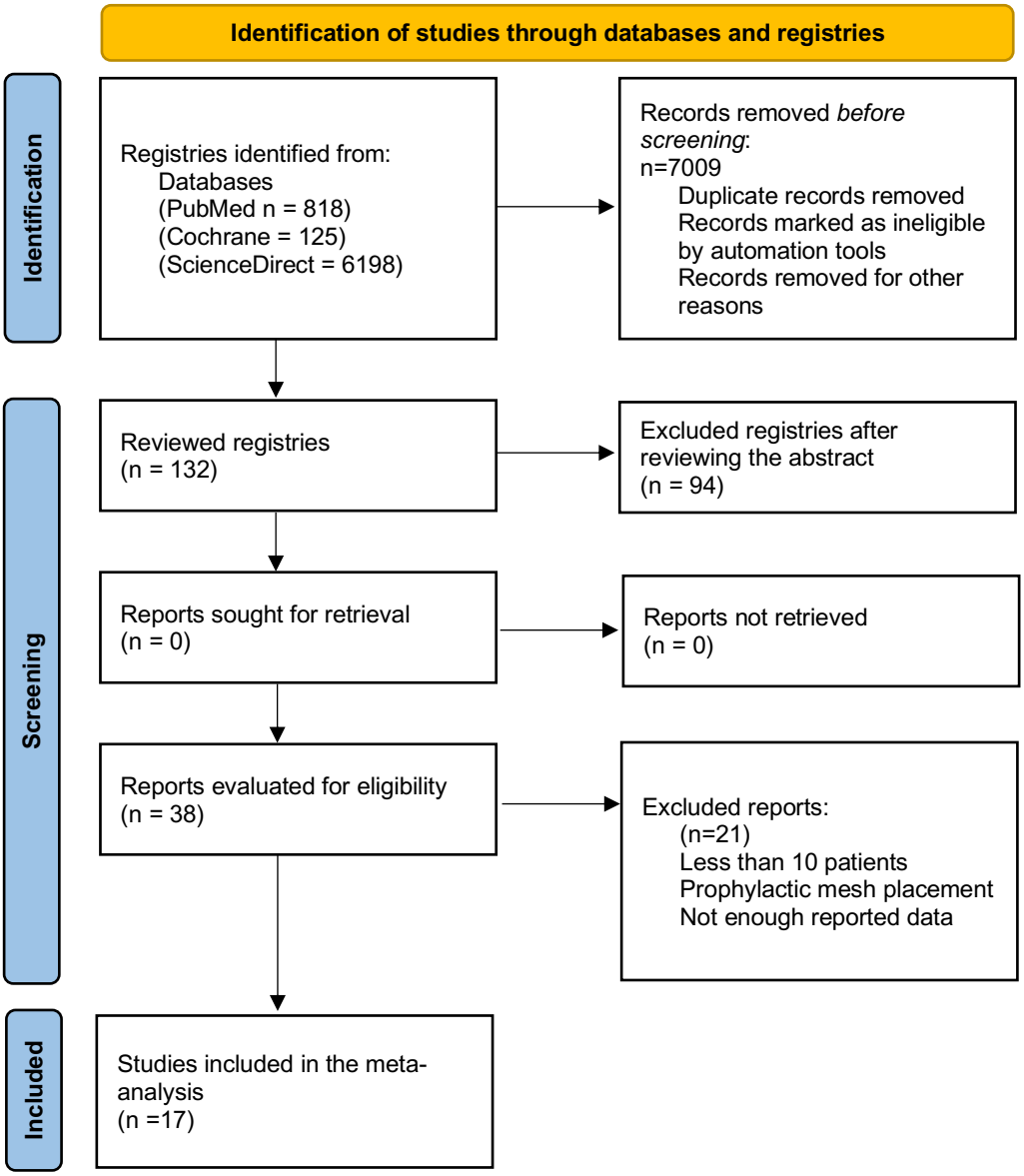
Two reviewers (D.C and C.R) independently assesed the quality of each study using the MINORS scale (15). Afterwards, their results were compared and a third reviewer (I.V) was involved to reach consensus when necessary.

Results

Literature search results

An online search found 943 registries. After an initial review 123 articles were selected out of which 85 were excluded after checking their abstracts. 38 articles were selected for a full-text revision. Lastly, 17 articles were considered eligible and were thus inputted into the meta-analysis model **(figure 1)**.

Figure 1. Flowchart representing information flow in each different stage for this systematic revision using PRISMA, The Preferred Reporting Items for Systematic reviews and Meta-Analyses.


Identification of studies through databases and registries
Identification
Registries identified from:
Databases
(PubMed n = 818)
(Cochrane = 125)
(ScienceDirect = 6198)
Records removed *before screening*:
n=7009
Duplicate records removed
Records marked as ineligible by automation tools
Records removed for other reasons
Screening
Reviewed registries
(n = 132)
Excluded registries after reviewing the abstract
(n = 94)
Reports sought for retrieval
(n = 0)
Reports not retrieved
(n = 0)
Reports evaluated for eligibility
(n = 38)
Excluded reports:
(n=21)
Less than 10 patients
Prophylactic mesh placement
Not enough reported data
Included
Studies included in the meta-analysis
(n =17)

Description of included studies

The 17 included studies included summed up a total of 2899 patients (median 164, interquartile range of 102.5). All studies were retrospective except for one prospective study and were published between 2006-2022. A summary of the included studies' characteristics can be seen in **table 1**.

Table 1. Included studies' characteristics.

Study	**Study design**	**Year**	**# of participants**	**Follow-up time**	**Incisional hernia incidence**
Calvo Espino, et al. (15)	Prospective	2022	202	46 (12 – 109) months	23%
Ramírez-Giraldo, et al. (16)	Retrospective	2022	164	35,21±18,42 months	22,7%
Bloomfield, et al. (17)	Retrospective	2022	171	>24 months	14,6%
Mongelard, et al. (18)	Retrospective	2020	91	47,6 (28,5 – 66,7) months	25,3%
Eklöv, et al. (19)	Retrospective	2020	216	30 (21 – 33) months	7,4%
Kelly-Schuette, et al. (20)	Retrospective	2020	243	49,5 (1 – 80) months	11,9%
De Robles, et al. (21)	Retrospective	2019	224	30,7±15,1 months	5,3%
Kaneko, et al. (22)	Retrospective	2018	134	47 (8 - 130) months	23,9%
Brook, et al. (23)	Retrospective	2018	193	20,5 (0 - 69 months)	13.5%
Amelung, et al. (24)	Retrospective	2018	318	24 (12 – 89) months	34.6%
Vergara-Fernández, et al. (25)	Retrospective	2018	136	12 months	11%
Oriel, et al. (26)	Retrospective	2017	114	68,4 (6-168) months	9,6%
Fazekas, et al. (27)	Retrospective	2016	121	4,4 (1 – 125) months	14,9%
De Keersmaecker, et al. (28)	Retrospective	2015	153	30,72±19,44 months	11,11%
Sharp, et al. (29)	Retrospective	2015	365	30 (1 – 144) months	18,6%
Cingi, et al. (30)	Retrospective	2008	31	26 (3–118) months	32%
Cingi, et al. (31)	Retrospective	2006	23	15 (2–63) months	48%

Characteristics of the risk factors associated with appearance of incisional hernia evaluated in the different included studies can be observed in **table 2**.

Table 2. Characteristics of the risk factors associated to appearance of incisional hernia in stoma site.

	Age	**Gender M – F (%)**	**BMI**	**Arterial hypertension (%)**	**Diabetes mellitus (%)**	**COPD (%)**	**Collagen disease (%)**	**Malignant disease**	**Active smoker**	**Stoma protection (%)**	**Anastomotic leak (%)**
Calvo Espino	64.5±9.95 years	29 (61,7) – 18 (38,3)	27,23±4,13 kg/m^2	NR	8 (17,0)	3 (6,3)	0 (0,0)	35 (74,4)	4 (8,5)	NR	NR
Ramírez-Giraldo	69,1±12,9 years	19 (46,34) - 22 (53,6)	25,52±3,82 kg/m^2	13 (31,7)	7 (17,0)	1 (2,4)	NR	26 (63,41)	8 (15,4)	12 (29,2)	1 (2,43)
Bloomfield	64.8±13.3 years	14 (56,0) - 11 (44,00)	30.1±6.54 kg/m^2	12 (48,00)	5 (20,00)	7 (28,00)	NR	19 (76,00)	4 (16,00)	NR	NR
Mongelard	NR	15 (65,21) – 8 (34,78)	NR	NR	3 (13,04)	1 (4,34)	NR	23 (100)	7 (30,43)	NR	NR
Eklöv	NR	14 (87,5) – 2 (12,5)	NR	NR	NR	NR	NR	16 (100)	0 (0,00)	NR	NR
Kelly-Schuette	61,8±11,8	14 (48,27) – 15 (51,72)	33,2±8.9 kg/m^2	NR	NR	5 (17,24)	NR	6 (20,68)	15 (51,72)	NR	NR
De Robles	55,8±7,3 years	7 (58,33) – 5 (41,66)	33,3±3,1 kg/m^2	NR	NR	NR	NR	6 (50,0)	NR	NR	NR
Kaneko	NR	18 (56,25)- 14 (43,75)	NR	18 (56,25)	5 (15,62)	1 (3,12)	NR	NR	5 (15,62)	NR	NR
Brook	63,0±1,4 years	14 (53,84) - 10 (38,46)	28,4±4,66 kg/m^2	10 (38,46)	2 (7,69)	NR	NR	13 (50,0)	4 (15,38)	NR	NR
Amelung	NR	52 (47,27) – 58 (52,72)	NR	47 (42,72)	15 (13,63)	6 (5,45)	NR	48 (43,63)	24 (21,81)	51 (46,36)	10 (9,09)
Vergara-Fernández	NR	NR	NR	NR	NR	NR	NR	3 (20,0)	NR	15	NR
Oriel	NR	11 (100) – 0 (0,00)	29,9±5,9 kg/m^2	NR	1	3	NR	2 (18,18)	6 (54,54)	NR	NR
Fazekas	60±13,46 years	10 (55,55) – 8 (44,44)	29,1±5,03 kg/m^2	NR	1 (5,55)	NR	NR	18 (100)	2 (11,11)	18 (100)	NR
De Keersmaecker	NR	13 (76,46) – 4 (23,52)	NR	NR	2 (11,76)	2(11,76)	NR	17 (100)	NR	17 (100)	NR

Sharp	NR	NR	NR	NR	8 (11.76)	NR	NR	16	30	NR	NR
Cingi 2008	60,9±11, 0 years	4 (40,0) – 6 (60,0)	30,1±6,2 kg/m^2	NR	NR	NR	NR	NR	NR	NR	NR
Cingi 2006	59,5±17, 7 years	7 - 4	27,3±5,8 kg/m^2	NR	NR	NR	NR	NR	NR	NR	NR
NR: Not reported as a mean (standard deviation) or proportion											

(…continuation of table 2…)

	Adjuvant therapy (%)	**Neoadjuvant therapy (%)**	**Acute colonic obstruction (%)**	**Diverticulitis (%)**	**Right hemicolectomy (%)**	**Left hemicolectomy (%)**	**Subtotal colectomy**	**Sigmoidectomy (%)**	**Rectum resection (%)**	**Ileostomy (%)**
Calvo Espino	NR	25 (53,1)	NR	NR	NR	NR	NR	NR	NR	47 (100)
Ramírez-Giraldo	23 (56,09)	4 (9,75)	18 (43,9)	4 (9,7)	2 (4,87)	5 (12,19)	1 (2,43)	12 (29,26)	9 (21,95)	20 (48,78)
Bloomfield	NR	NR	NR	1 (4,00)	NR	NR	NR	NR	NR	25 (100)
Mongelard	12 (52,17)	NR	NR	NR	NR	NR	NR	NR	23 (100)	4 (17,39)
Eklöv	NR	NR	NR	NR	NR	NR	NR	NR	16 (100)	16 (100)
Kelly-Schuette	NR	NR	NR	18 (62,06)	NR	NR	NR	NR	NR	29 (100)
De Robles	NR	NR	1 (8,33)	2 (16,66)	2 (16,66)	NR	0 (0,00)	NR	0 (0,00)	12 (100)
Kaneko	18 (56,25)	NR	NR	0 (0,00)	NR	NR	NR	NR	NR	32 (100)
Brook	3 (11,53)	NR	NR	3 (11,53)	NR	NR	NR	NR	NR	26 (100)
Amelung	11 (10,0)	NR	24 (21,81)	NR	4 (3,63)	10 (9,09)	7 (6,36)	43 (39,09)	38 (34,54)	36 (32,72)
Vergara-Fernández	NR	NR	NR	NR	NR	NR	NR	NR	NR	15 (100)
Oriel	NR	NR	NR	6 (55,54)	NR	NR	NR	NR	NR	6 (54,54)
Fazekas	7 (38,88)	NR	NR	NR	NR	NR	NR	NR	18 (100)	18 (100)
De Keersmaecker	9 (52,94)	NR	NR	NR	NR	NR	NR	NR	17 (100)	17 (100)
Sharp	NR	NR	NR	15 (22,05)	NR	NR	NR	NR	NR	44 (64,70)
Cingi 2008	NR	NR	NR	NR	NR	NR	NR	NR	NR	2 (20,0)
Cingi 2006	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

NR: Not reported as a mean (standard deviation) or proportion

(…table 2 continuation)

	Colostomy (%)	Loop stoma (%)	End stoma (%)	Parastomal hernia (%)	Prolapsed stoma (%)	Continuous suture technique (%)	Intermittent suture technique (%)	Localized closure (%)	Laparoscopic closure (%)	Laparotomy closure (%)	Time interval until closure
Calvo Espino	NR	NR	NR	NR	NR	47 (100)	0 (0,00)	NR	9 (19,1)	38 (80,8)	NR
Ramírez-Giraldo	21 (51,21)	12 (29,26)	29 (70,73)	11 (26,82)	3 (7,31)	32 (78,04)	9 (21,95)	23 (56,09)	7 (17,07)	11 (26,82)	16,12±8,45 months
Bloomfield	0 (0,00)	NR	NR	NR	NR	NR	NR	NR	16 (64,0)	9 (36,0)	8.93±4.88 months
Mongelard	19 (82,60)	NR	NR	NR	NR	21 (91,30)	0 (0,00)	22 (95,65)	NR	1 (4,34)	NR
Eklöv	0 (0,00)	16 (100)	0 (0,00)	NR	NR	NR	NR	NR	0 (0,00)	16 (100)	NR
Kelly-Schuette	0 (0,00)	29 (100)	0 (0,00)	NR	NR	NR	NR	NR	NR	NR	NR
De Robles	0	10 (83,33)	2 (16,66)	NR	NR	NR	NR	11 (91,66)	6 (50,00)	NR	9,5±18,8 months
Kaneko	0 (0,00)	32 (100)	0 (0,00)	NR	NR	NR	NR	NR	NR	NR	NR
Brook	0 (0,00)	26 (100)	0 (0,00)	NR	NR	NR	NR	NR	NR	NR	5,4±1,8
Amelung	74 (67,27)	12 (10,90)	98 (89,09)	10 (9,09)	13 (11,81)	26 (26,26)	73 (73,73)	94 (85,45)	2 (1,81)	14 (12,72)	NR
Vergara-Fernández	0 (0,00)	15 (100)	0 (0,00)	5 (33,33)	NR	NR	NR	NR	NR	NR	NR
Oriel	5 (45,45)	4	7	3	0	3 (30.0)	7 (70.0)	4 (36,36)	NR	7 (63,63)	8,17±7,28
Fazekas	0 (0,00)	18 (100)	0 (0,00)	NR	NR	NR	NR	NR	NR	NR	10,9±12,8
De Keersmaecker	0 (0,00)	17 (0,00)	NR	NR	NR	NR	NR	NR	NR	NR	NR

Sharp	24 (35,29)	52 (76,47)	16 (23,52)	NR	NR	0 (0,00)	68 (100)	NR	NR	NR	NR
Cingi 2008	8 (80,0)	5 (50,0)	5 (50,0)	NR	NR	NR	NR	NR	NR	NR	5,2±3,2
Cingi 2006	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
NR: Not reported as a mean (standard deviation) or proportion											

Quality assessment was performed according to MINORS instrument, where an ideal global score for non-comparative studies is 16 and 24 for comparative studies (14). Due to this subdivision and total score discrepancy between comparative and non-comparative studies, results were converted into percentages to avoid confusion. The lowest scoring studies were of 56,2% while the highest scoring study was of 81,2%, with a median of 68,7%. The quality of each of the included studies is reported in **table 3**.

Table 3. Quality of the studies included according to the MINORS scale.

Study	**Quality assessment**	**Quality assessment (D.C)**	**Quality assessment (C.R)**
Calvo Espino	68,7%	75,3%	62,1%
Ramírez-Giraldo	75,0%	72,3%	77,7%
Bloomfield	56,2%	54,6%	57,8%
Mongelard	68,7%	75,3%	62,1%
Eklöv	68,7%	75,3%	62,1%
Kelly-Schuette	81,2%	86,1%	76,3%
De Robles	56,2%	54,6%	57,8%
Kaneko	75,0%	72,3%	77,7%
Brook	62,5%	63,4	61,6
Amelung	75,0%	72,3%	77,7%
Vergara-Fernández	62,5%	63,4	61,6
Oriel	75,0%	72,3%	77,7%
Fazekas	68,7%	62,1%	75,3%
De Keersmaecker	75,0%	77,7%	72,3%
Sharp	75,0%	77,7%	72,3%
Cingi	62,5%	61,6	63,4
Cingi	68,7%	75,3%	62,1%

Incidence

Incisional hernia appearance after stoma closure's pooled incidence was of 16.76% [CI95% 12.82; 21.62] between included studies using a random effects model and high heterogeneity (I^2=89.9%, Cochran's Q test, p<0.001) **(figure 2)**. There was not any evidence of publication bias using the Eggers test (p=0.0656) **(figure 3)**.

Figure 2. Forest plot showing pooled incidence.

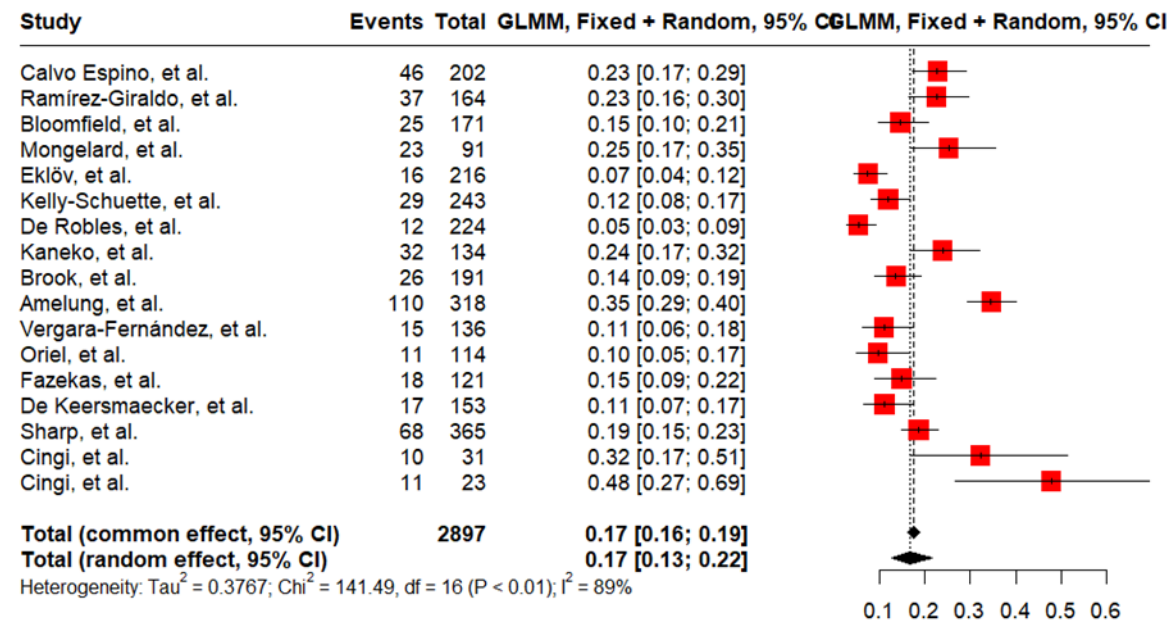
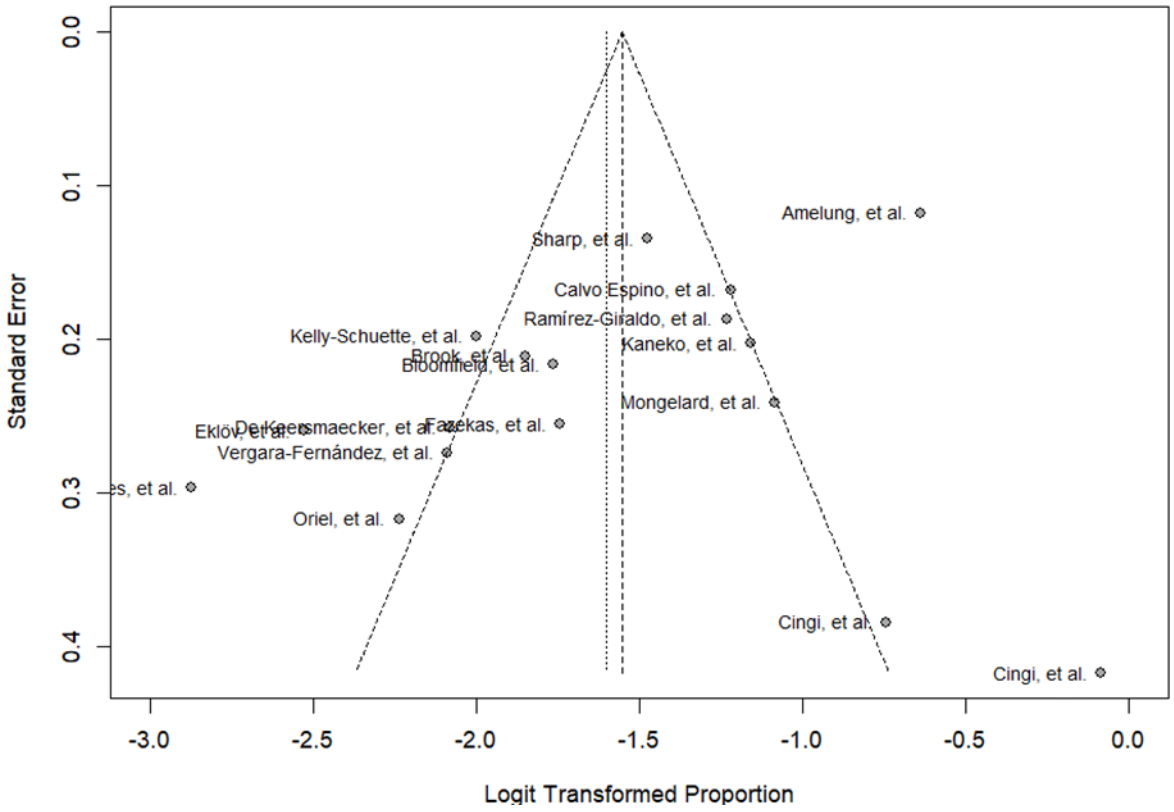


Figure 3. Funnel plot for publication bias assessment.



Risk factors

Age

Out of the 9 studies that reported age as a risk factor for appearance of incisional hernia in stoma closure site, there was not a statistically significant difference (p=0.3058) using a random effects model and high heterogeneity (I^2=95.5%,Cochran's Q test, p<0.001). There was not any evidence of publication bias using the Eggers test (p=0.9623).

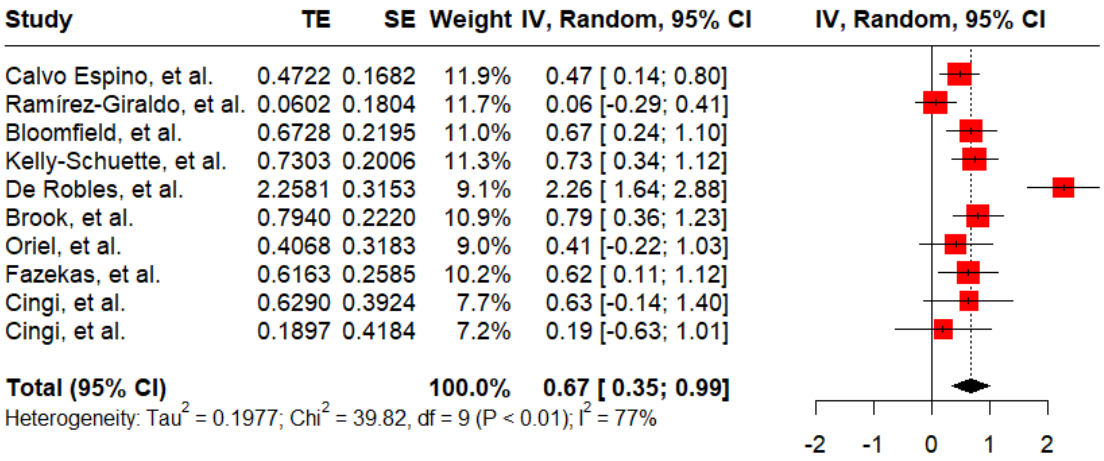
Gender

Out of the 15 studies reporting gender as a risk factor for inicisional hernia in stoma closure site, there was not a statistically significant difference (p=0.5230) using a random effects models and low heterogeneity (I^2=0%, Cochran's Q test, p=0.7758). There was not any evidence of publication bias using the Eggers test (p= 0.3690).

BMI

In the 10 studies that reported BMI as a risk factor for presenting incisional hernia in stoma site, using a random effects models and high heterogeneity (I^2=77.4%,Cochran's Q test, p=0.0001), a statistically significant higher risk was evidenced in patients with a higher BMI (p<0.0001). There was not any evidence of publication bias using the Eggers test (p=0.3561) **(figure 4).** In the sensitivity analysis for this outcome, no significant variations in the estimates were found when each one of the studies was excluded.

Figure 4. Forest plot for BMI as a risk factor.



In the 5 included studies that evaluated arterial hypertension as a risk factor for the presence of incisional hernia in stoma site after its closure, there was not a statistically significant difference (p=0.6106) using a random effects model and high heterogeneity (I^2=82.7%,Cochran's Q test, p=0.0001). There also was not any evidence of publication bias using the Eggers test (p=0.5310).

Diabetes mellitus

In the 11 studies that evaluated diabetes mellitus as a risk factor for the appearance of incisional in stoma site after closure, there was not a statistically significant difference (p=0.1118) using a random effects model and high heterogeneity (I^2=0%, Cochran's Q test, p=0.7866). There also was not any evidence of publication bias using the Eggers test (p=0.2517).

COPD

In the 9 included studies that evaluated COPD as a risk factor for the appearance of incisional in stoma site after closure, there was not a statistically significant difference (0.1143) using a random effects model and low heterogeneity (I^2=0%, Cochran's Q test, p=0.7425). There also was not any evidence of publication bias using the Eggers test (p=0.5798).

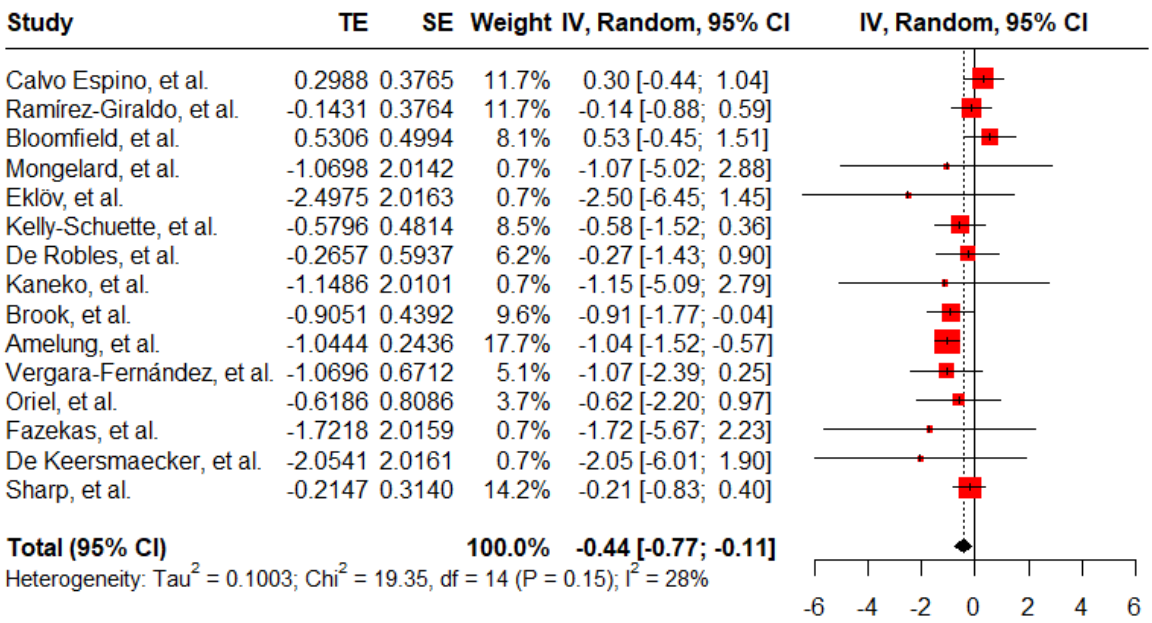
Tobacco use

In the 12 studies that evaluated tobacco use as a risk factor for the appearance of incisional in stoma site after closure, there was not a statistically significant difference (p=0.5589) using a random effects model and moderate heterogeneity (I^2=40.6%, Cochran's Q test, p=0.0702). There was also not any evidence of publication bias using the Eggers test (p=0.9106).

Malignant disease

In the 15 included studies that evaluated malignant disease as a risk factor for incisional hernia appearance in stoma site, a lower risk of incisional hernia appearance was found in patients presenting with malignant disease (p=0.0084) using a random effects model and moderate heterogeneity (I^2=27.7%,Cochran's Q test, p=0.1518). There was not any evidence of publication bias using the Eggers test (p=0.5862) **(figure 5)**.In the sensitivity analysis for this outcome, only a significant variation of the estimates was found when the study of Amelung, et al. was excluded.

Figure 5. Forest plot for malignant disease as a risk factor



Diverticular disease

In the 7 studies that evaluated diverticular disease as a risk factor for the appearance of incisional in stoma site after closure, there was not a statistically significant difference (p=0.4143) using a random effects model and moderate heterogeneity (I^2=74.5%, Cochran's Q test, p<0.0006). There also was not any evidence of publication bias using the Eggers test (p=0.1012).

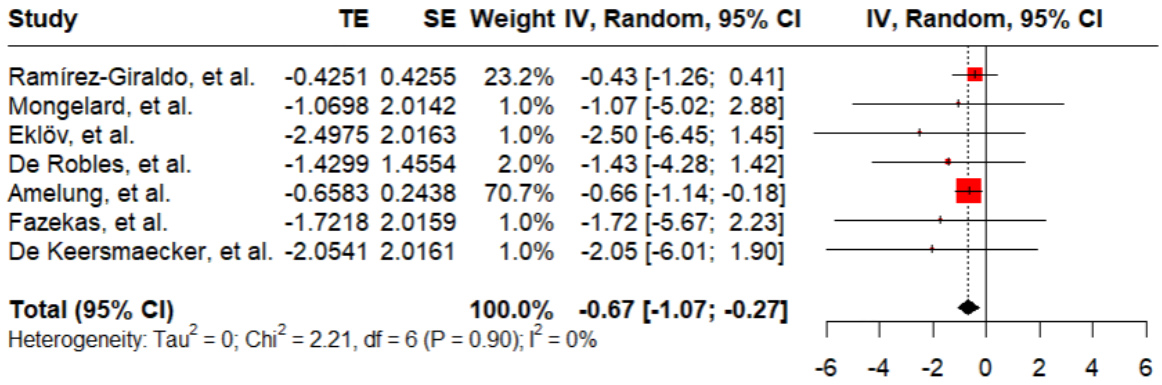
Adjuvant therapy

In the 7 studies that evaluated adjuvant therapy as a risk factor for the appearance of incisional in stoma site after closure, there was not a statistically significant difference (p=0.9850) using a random effects model and moderate heterogeneity (I^2=32.3%,Cochran's Q test, p=0.1815). There also was not any evidence of publication bias using the Eggers test (p=0.8546).

Rectum anterior resection

In 7 of the included studies that evaluated rectum anterior resection as a risk factor for incisional hernia in stoma site after closure when comparing it to other types of resections (e.g. right hemicolectomy, sigmoidectomy, amongst others), a statistically significant difference was found associated with a lower risk of presenting incisional hernia in stoma site after closure (p=0.0011) using a random effects model and low heterogeneity (I^2=0%, Cochran's Q test, p=0.8993). There also was not any evidence of publication bias using the Eggers test (p=0.0305) **(figure 6)**. In the sensitivity analysis for this outcome, only a significant variation of the estimates was found when the study of Amelung, et al. was excluded.

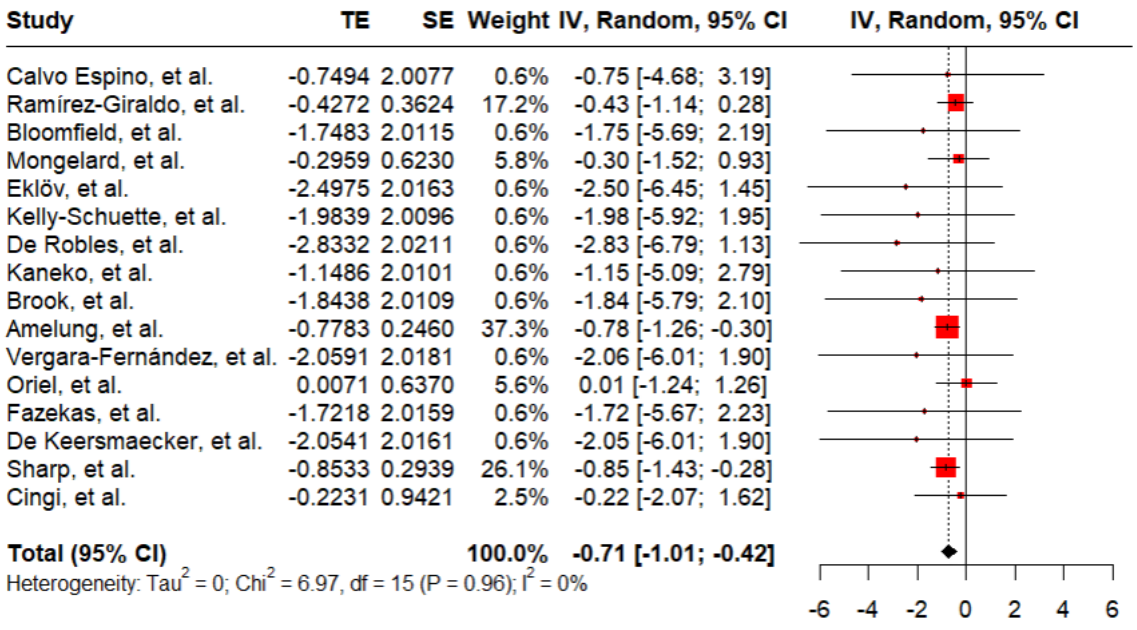
Figura 6. Forest plot for rectum anterior resection as a risk factor.



Ileostomy vs colostomy

In the 16 included studies that evaluated ileostomy as a risk factor for appearance of incisional hernia in stoma site after closure, a statistically significant difference was found associated with a lower risk of presenting incisional hernia in stoma site after closure (p=0.0011) when performing a ileostomy compared to colostomy using a random effects model and low heterogeneity (I2=0%, Cochran's Q test, p=0.9586). There also was not any evidence of publication bias using the Eggers test (p=0.0691) (figure 7). In the sensitivity analysis for this outcome, no significant variations in the estimates were found when each one of the studies was excluded.

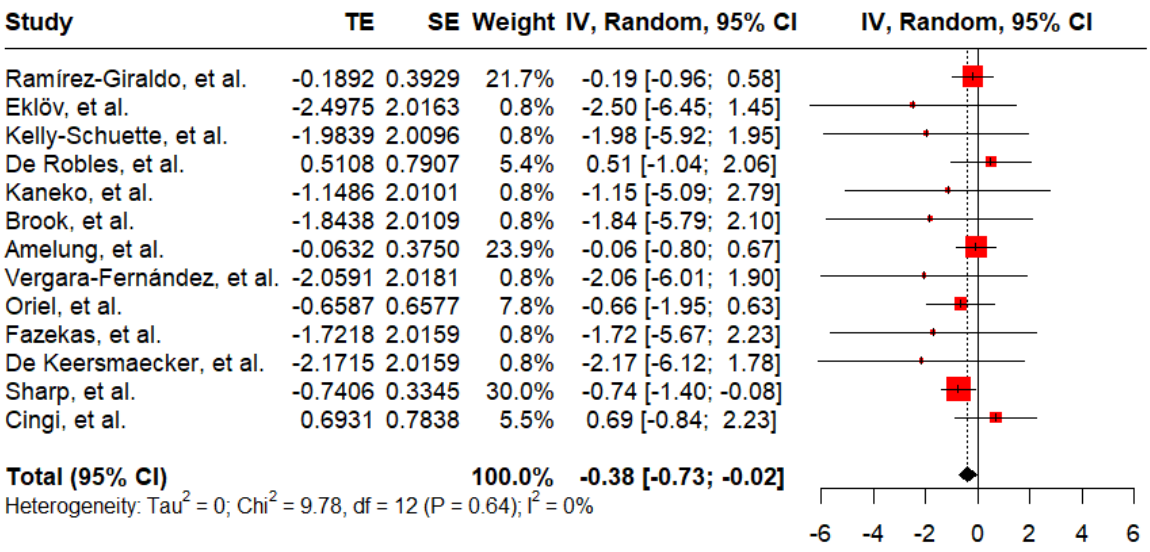
Figure 7. Forest plot for ileostomy vs colostomy as a risk factor.



Loop vs end stoma

In the 13 included studies that evaluated loop stoma as a risk factor for presenting incisional hernia in stoma site after its closure, a statistically significant difference was found associated with a low risk of presenting incisional hernia in stoma site after closure when performing a loop stoma compared to an end stoma (p= 0.0405). This was done using a random effects model and low heterogeneity (I2=0%, Cochran's Q test, p=0.6357). There also was not any evidence of publication bias using the Eggers test (p=0.1162) (figure 8). In the sensitivity analysis, small variations were found in the estimations when articles by Eklöv, et al., Oriel, et al. and De Keersmaecker, et al. were excluded.

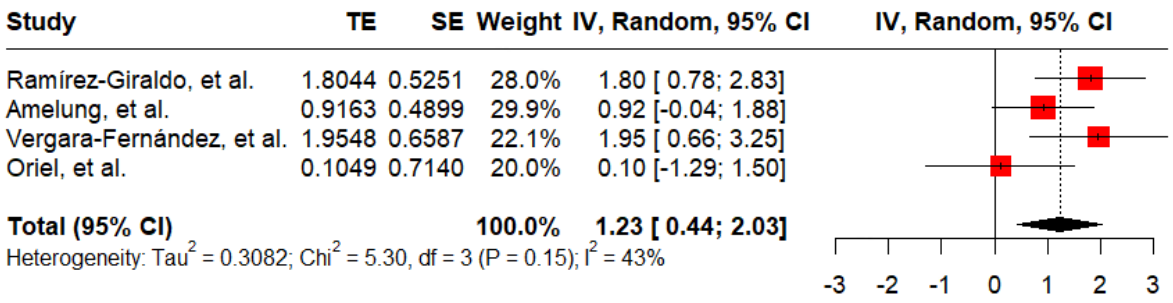
Figure 8. Forest plot for loop vs end stoma as a risk factor.



Parastomal hernia

In the 4 included studies that evaluated parastomal hernia as a risk factor for incisional hernia in stoma site after closure, a statistically significant difference was found associated with a high risk of presenting incisional hernia in stoma site after closure (p=0.0023) using a random effects model and moderate heterogeneity (I^2=43.4%,Cochran's Q test, p=0.1514). There also was not evidence of publication bias using the Eggers test (p=0.7742) **(figure 9)**. In the sensitivity analysis for this outcome, no significant variations in the estimates were found when each one of the studies was excluded.

Figure 9. Forest plot for parastomal hernia as a risk factor.



Prolapsed stoma

In 3 of the included studies that evaluated prolapsed stoma as a risk factor for the appearance of incisional in stoma site after closure, there was not a statistically significant difference (p=0.4580) using a random effects model and moderate heterogeneity (I^2=32.9%, Cochran's Q test, p=0.2254). There also was not any evidence of publication bias using the Eggers test (p=0.7539).

Abdominal wall closure technique (intermittent versus continuous)

In 6 of the included studies that evaluated abdominal wall closure technique (intermittent vs cotinuous suture) as a risk factor for the appearance of incisional in stoma site after closure, there was not a statistically significant difference (p=0.1124) using a random effects model and low heterogeneity (I^2=0%, Cochran's Q test, p=0.8768). There also was not any evidence of publication bias using the Eggers test (p=0.7717).

Localized closure

In 5 of the included studies that evaluated localized closure as a risk factor for the appearance of incisional in stoma site after closure, there was not a statistically significant difference (p=0.2155) using a random effects model and low heterogeneity (I^2=0.9%, Cochran's Q test, p=0.4011). There also was not any evidence of publication bias using the Eggers test (p=0.1827).

Laparoscopic closure

In the 6 of the included studies that evaluated laparoscopic closure as a risk factor for the appearance of incisional in stoma site after closure, there was not a statistically significant difference (p=0.8343) using a random effects model and low heterogeneity (I^2=7.9%,Cochran's Q test, p=0.3659). There also was not any evidence of publication bias using the Eggers test (p= 0.4474).

Laparotomy closure

In the 7 studies that evaluated laparotomy closure as a risk factor for the appearance of incisional in stoma site after closure, there was not a statistically significant difference (p=0.3999) using a random effects model and low heterogeneity (I^2=0%, Cochran's Q test, p=0.8146). There also was not any evidence of publication bias using the Eggers test (p=0.3396).

Time interval until closure

In the 7 studies that evaluated late stoma closure as a risk factor for the appearance of incisional in stoma site after closure, there was not a statistically significant difference (p=0.2299) using a random effects model and moderate heterogeneity (I^2=66.3%,Cochran's Q test, p=0.0067). There also was not any evidence of publication bias using the Eggers test (p=0.9366).

Discussion

After performing a meta-analysis on 17 studies that totaled 2899 patients, the following risk factors were found for incisional hernia appearance in stoma site after its closure: higher BMI, parastomal hernia, colostomy, and end stoma. On the other side, malignant disease and rectum anterior resection were found to be protective factors. This can be explained because loop ileostomies are associated with a lesser risk of presenting incisional hernia and are preferred over colostomies when faced with rectum resection by malignant disease as they provide superior protection of the colorectal anastomosis.

Higher BMI is a risk factor that is typically associated not only with incisional hernia presentation but with primary and recurrent herniation as well (35–38). In multiple of the studies included and even in some were inclusion criteria were not met, it was reported as a risk factor for incisional hernia after stoma site closure (39–41). Taking all of this into consideration and with the evidence found in this meta-analysis this group of patients would be candidates for prophylactic mesh placement. It is also important to remember the risks of performing an additional procedure such as mesh placement, in addition to the increased technical difficulty in mesh placement on patients with a higher BMI. A cut-off point in which we determine which patients with a higher BMI are appropriate candidates for prophylactic mesh placement must be established due to the fact we evidenced it as a risk factor for developing an hernia in stoma closure and that we analyzed this variable a continuous variable as most studies report them this way.

Complications associated with the stoma such as parastomal hernia and prolapsed stoma have been described as risk factors for incisional hernia appearance in stoma site after closure (40,42). In this study we did not find any statistically significant differences for prolapsed stoma. However, parastomal hernia was associated with a higher risk of developing incisional hernia. This can be explained by the fact that a parastomal hernia implies a bigger fascial defect and a weaker abdominal wall, which can then predispose the patient to the appearance of incisional hernia. Furthermore, we have to recognize that these patients already presented an hernia defect, the appearance of which was probably associated to already present risk factors associated to parastomal hernia. These could be shared with risk factors associated to stoma closure (43). One of the limitations of this study was that in none of the included studies that evaluated parastomal hernia as a risk factor, classified them according to the European Hernia Society classification of parastomal hernias but rather only the presence or absence of (19,44).

Regarding the type of stoma both colostomy and ileostomy have been already evaluated. In a previous meta-analysis in which both types of stoma were compared a statistically significant difference was not found (11), however other studies have reported a higher incidence of incisional hernia in colostomy cases. This can be explained due to the need of performing a larger incision in colostomies considering the large intestine's wider diameter compared to the small intestine. In this meta-analysis we found that performing a colostomy is associated with a higher rate of incisional hernia as well as end stomas, which are then performed mostly in the case of a colostomy.

Another risk factor described in the literature is arterial hypertension, which has been associated to pathological scarring due to inflammation, hypoxia, and the renin-angiotensin-aldosterone system. However, in this study we didn't find a statistically significant difference in arterial hypertension as a risk factor (LogOR=0,23, IC 95%=-0,66 - 1,11, p=0,60) (24,41).

Closure approach is another described risk factor for appearance of incisional hernia including localized, laparoscopic or laparotomy closure. However, we didn't find a statistically significant difference for any of the described methods nor for abdominal wall closure technique (intermittent or continuous suture).

Hernias are a complex and well-known medical problem, in which the patient can experience pain, impossibility to work, disfiguring and body image issues, decrease in the quality of life and requiring an emergency abdominal surgery due to intestinal obstruction or strangulation (1). One of the alternatives to help prevent incisional hernia and their consequences are the use of a prophylactic mesh, which have been proven to reduce incisional hernia rates after stoma closure (6,46,47).

A recent analysis on cost-effectivity for prophylactic mesh placement during stoma closure evidenced it to not be cost-effective. However, the named analysis was performed alongside the ROCSS clinical trial in which a biological, more expensive type of mesh was used (8,48). Studies evaluating other types of mesh that are more affordable are not available in the current literature and should be considered as a more effective alternative (49–51). Moreover, a high-risk focus could be considered to improve cost-efficiency by considering prophylactic mesh placement exclusively in patients with a risk factor for the development of incisional hernia at the stoma site after its closure. Taking into account what was previously stated and this study's results, patients that would currently benefit from prophylactic mesh placement in stoma site during stoma closure would be obese patients, patients with parastomal hernias and patients with colostomies or end stomas. It is important to consider that prophylactic mesh placement is an additional procedure, and as a result the risk-benefit for this procedure should be evaluated accordingly, such as a higher probability of presenting an incisional hernia and its consequences, such as an urgent or scheduled reintervention due to complications such as incarceration, and on the other side, the risk of infection or seroma associated to mesh placement, amongst others.

Currently, more studies that focus on high-risk populations that would benefit from prophylactic mesh placement during stoma closure for prevention of incisional hernia appearance in stoma site are needed. Studies of higher quality for identifying risk factors are also needed in the current literature. It is also necessary to perform studies with a high-risk emphasis, in which prophylactic mesh placement is evaluated in high-risk patients versus not placing a prophylactic mesh in patients with no risk factors. This would allow us to review procedure efficacy and its cost-effectiveness compared to prophylactic mesh placement in all patients regardless of their risk factors.

This systematic review has some limitations. Most included studies were retrospective except for one, which have a potential bias for results' analysis or data loss during follow-up. According to the MINORS scale quality of the included articles was moderate. The variability of the different ways in which patients' characteristics were reported caused some data loss and some variables are not clearly defined such as hypertension or COPD. Additionally, we did not include gray literature. Furthermore, some of the characteristics we were interested in evaluating were not reported.

Conclusion

Prophylactic mesh placement should be considered as an effective preventative intervention in high-risk patients (higher BMI, patients with parastomal hernia and colostomy and end stoma patients) with the goal of reducing incisional hernia rates in stoma site after closure while remaining cost-effective.

Supplement 1

Sensitivity analyses.

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