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Outcomes of Hartmann's procedure and subsequent intestinal restoration. Which patients are most likely to undergo reversal?

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ABSTRACT

Background: Aim of the study was to describe characteristics and outcomes of Hartmann's procedure (HP) and subsequent intestinal restoration.
Methods: Retrospective study including all patients who underwent HP over a period of 16 consecutive years. We propose a classification and regression tree for a more accurate view of the relationship between the variables related to intestinal restoration and their weighting in the decision to reverse HP.
Results: 533 patients were included. Overall morbidity rate of HP was 53.5% and mortality 21.0%. Overall morbidity of the intestinal continuity reconstruction was 47.3% and mortality 0.9%. Patients with a benign disease, aged under 69 years and with low comorbidity, had an 84.4% probability of undergoing intestinal reconstruction.
Conclusions: HP is associated with high morbidity and mortality. Restoration of intestinal continuity involves minor, but frequent, morbidity and a low mortality rate. Age and comorbidities can decrease, and even override, the decision to reverse HP.

Introduction

Urgent surgery involving a Hartmann's Procedure (HP) is still associated with a high postoperative morbidity rate of up to 50%, and a significant mortality rate, ranging from 15 to 25%.[1–13] Morbidity of HP is mainly due to septic complications, such as wound infection or intra-abdominal abscesses, and cardiorespiratory complications. Stoma-related complications are also quite common, ranging between 21% and 70%.[3,4,14,15]

Restoring intestinal continuity after HP involves readmission and is frequently associated with a not negligible postoperative morbidity, that in some series reaches up to 50%, and a risk of mortality higher than 5%.[1,13,16–20] The most frequent complications reported are wound infection, cardiorespiratory morbidity, anastomotic leakage and stenosis of the anastomosis.[16,21–26] Because of the serious morbidity and mortality related to HP and its subsequent reversal, the incidence rates for the reversal procedure are usually low, ranging from 23% to 70% of patients who survive the first intervention.[7,13,17,18,21–24,27–31]

The aim of the study was to describe HP patient characteristics, and analyse the main features and outcomes of this procedure and the second operation to restore intestinal continuity. We also determined the frequency of both surgical procedures in our hospital, their temporal evolution and each patient probability of intestinal restoration.

Material and methods

Study design

An observational, retrospective and longitudinal study, analysing a cohort of patients undergoing HP from January 1999 to December 2014 in the Colorectal Unit of the Hospital Clínico Universitario of Valencia, Spain.

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Patients

The cohort included all patients who underwent urgent or elective resection of the descending colon, sigmoid or rectum, leaving the rectal stump closed and a proximal end colostomy in the left iliac fossa. No exclusion criteria were applied.

Variables

Patient data were obtained from hospital and primary care clinical records.

Quantitative variables

We compiled data on duration of HP, hospital stay and time lag to HP reversal. Some continuous quantitative variables were also collected, such as age, body mass index (BMI), the Charlson index at the time of colon resection and finally volumes of pre- and post-operative blood transfusion. For these last quantitative factors the significant cut-off points for intestinal reconstruction were established for our series using the R-Core Team Optimal Cut-Points library.

Qualitative variables

Gender, preoperative anal incontinence, type of pathology (benign or malignant), ASA score, main diagnosis, tumour stage, degree of peritonitis, indication of HP, main surgical procedure, type of surgery (urgent or elective), type of surgeon (general or colorectal), length of the rectal stump, Clavien-Dindo classification of complications after HP, early readmission after HP, reason for ruling out reversal procedure, Clavien-Dindo classification of complications after the reconstructive procedure, early readmission after this last procedure, mortality of HP and HP reversal, and lastly cause of death.

Ethics

The study was approved by the local ethical committee of the University Clinical Hospital of Valencia.

Statistical analysis

We created a database including all prospectively compiled patient data for further analysis. Initially, a descriptive study of the sample was carried out, through an analysis of the characteristics of each of the variables to be studied. Further, χ^2 test or Fisher's exact test looked for possible differences between patients that underwent urgent or elective surgery and between patients with benign or malignant disease. For the qualitative variables we used the distribution values of frequencies and proportions, expressed in percentages. To determine if the quantitative variables followed a normal distribution, the Kolmogorov-Smirnov and Shapiro-Wilk tests were applied. Given a non-normal distribution we chose the median with interquartile range as descriptive parameters. Some quantitative variables (age, BMI and Charlson index) were discretized determining the significant cut points for this series using the R-Core Team Optimal-Cut-Points library.[32]

We analysed how often patients who had previously undergone a HP subsequently underwent a reversal procedure. We also studied how the frequency of HP and subsequent intestinal reconstruction evolved over time. Furthermore, we created a classification and regression tree to assess the relationship between the variables related to restoration of intestinal continuity, and determine the rules to classify the decision to reverse the HP. Each variable in the classification and regression tree was also weighted. Additionally, the classification tree allowed us to assess patient risk based on the variables represented on the different classification branches. Data were analysed with SPSS® v.20 (SPSS Inc. Chicago, Illinois, USA) and R Core Team (R Foundation for Statistical Computing, Vienna, Austria, 2013) software.

Results

Patient features

The study included 533 patients who underwent HP over a period of 16 consecutive years. Table 1 shows the participating patients' characteristics.

The mean age was 71.7 years (standard deviation: 13.1, range: 23–101). The median BMI was 26.9 (Range: 16.1–58.7, Interquartile range: 23.7–29.9). Most patients presented with an ASA score III (55.9%) and accordingly more than half of the patients (59.5%) had a high Charlson index (≥6). Patients who underwent urgent HP had lower age (age < 69 years: 39.7%), ASA score (I-II: 34.7%), Charlson index (<6: 48.2%) and also lower frequency of preoperative anal incontinence (0.2%) than those who underwent elective surgery. Urgent surgery cases presented more frequently benign diseases (53.2% vs. 8.8%) and had a higher intestinal restoration rate (27.3% vs. 6.5%). Additionally, in the comparison of the groups according to the type of disease, patients with benign pathologies presented a lower Charlson index (62.5% vs. 26.5%) and a higher frequency of intestinal restoration (28.4% vs. 15.7%).

Characteristics of Hartmann's procedure

Table 2 summarizes the characteristics related to HP. The median hospital stay was 14 days (range: 1–180, interquartile range: 9–24). The median operative time was 180 min (range: 35–600, interquartile range: 135–225). The patients received an average of 1.05 (standard deviation: 2.3) red blood cell concentrates perioperatively; however, the majority (68.7%) did not require perioperative blood transfusion. They received an average of 1.74 (standard deviation: 3.7) red cell concentrates in the postoperative period and the majority of patients did not require a postoperative transfusion (62.3%). The patients who underwent elective surgery received more frequently perioperative transfusion (41.2% vs 26.7%). The group of urgent surgery showed more often peritonitis than the elective group (75.6% vs. 6.5%). However, the patients with benign disease presented more frequently peritonitis than those with malignant disease (82.1% vs. 30.5%).

The indication of HP was mainly due to risk of anastomotic leakage in urgent surgery (81.8% vs. 47.6%) and also in those patients with benign disease (94.2% vs. 56.0%). The surgeon was predominantly a general surgeon in the urgent group (67.5% vs. 4.7%) and in the group of benign disease (68.3% vs. 34.2).

The rectal stump of the patients who underwent urgent HP was more frequently located at the sacral promontory (87.9%), as well as in those patients with benign disease (92.3%).

The overall morbidity was 53.5%. According to the Clavien-Dindo classification 25.2% of patients had type I or II complications, 13.7% type III complications and 14.6% type IV. Patients in the urgent surgery group presented more morbidity than those in the elective surgery group (80.4% vs. 61,7%).

Table 3 shows the morbidity of HP. Cardiopulmonary morbidity (34.3%) and wound infection (16.9%) were the most common complications. In the emergency setting cardiopulmonary morbidity (41.0% vs. 20.0%), stoma complications (8.8% vs. 2.4%) and wound dehiscence (5.8% vs. 0.6%) were more frequent than in elective surgery. Regarding the type of disease, only

Table 1
Characteristics of the 533 patients who underwent Hartmann's procedure.

	Total (*n = 533*)	Type of Surgery			Disease		
	n (%)	Urgent (*n = 363*) n (%)	Elective (*n = 170*) n (%)	*p*	Benign (*n = 208*) n (%)	Malignant (*n = 325*) n (%)	*p*
Age							
<69 years	181 (34.0)	144 (39.7)	37 (21.8)	*0.00*	76 (36.5)	105 (32.3)	*0.35*
≥69 years	352 (66.0)	219 (60.3)	133 (78.2)		132 (63.5)	220 (67.7)	
Gender							
Male	288 (54.0)	206 (56,7)	82 (48.2)	*0.07*	104 (50.0)	184 (56.6)	*0.15*
Female	245 (46.0)	157 (43.3)	88 (51.8)		104 (50.0)	141 (43.4)	
BMI							
<30	291 (75.6)	177 (73.4)	114 (79.2)	*0.22*	95 (74.2)	196 (76.3)	*0.70*
≥30	94 (24.4)	64 (26.6)	30 (20.8)		33 (25.8)	61 (23.7)	
ASA							
I	38 (7.1)	37 (10.2)	1 (0.6)	*0.01*	18 (8.7)	20 (6.2)	*0.49*
II	136 (25.5)	89 (24.5)	47 (27.6)		57 (27.4)	79 (24.3)	
III	298 (55.9)	198 (54.5)	100 (58.8)		112 (53.8)	186 (57.2)	
IV	61 (11.5)	39 (10.7)	22 (12.9)		21 (10.1)	40 (12.3)	
Charlson index							
Low (<6)	216 (40.5)	175 (48.2)	41 (24.1)	*0.00*	130 (62.5)	86 (26.5)	*0.00*
High (≥6)	317 (59.5)	188 (51.8)	129 (75.9)		78 (37.5)	239 (73.5)	
Anal incontinence							
Yes	22 (4.2)	1 (0.2)	21 (3.9)	*0.00*	11 (5.3)	27 (8.3)	*0.23*
No	511 (95.8)	532 (99.8)	512 (96.1)		196 (94.7)	297 (91.7)	
Diseases							
Benign	208 (39.0)	193 (53.2)	15 (8.8)	*0.00*			-
Malignant	325 (61.0)	170 (46.8)	155 (91.2)		–	–	
Diagnosis							
Descendent colon neoplasm	26 (4.9)	22 (6.1)	4 (2.4)	*0.00*	0 (0.0)	26 (8.0)	*0.00*
Sigmoid colon neoplasm	186 (34.9)	122 (33.6)	64 (37.6)		3 (1.4)	183 (56.3)	
Rectum neoplasm	114 (21.4)	26 (7.2)	88 (51.8)		1 (0.5)	113 (34.8)	
Diverticular disease	140 (26.2)	133 (36.6)	7 (4.1)		139 (66.8)	1 (0.3)	
Sigmoid volvulus	24 (4.5)	19 (5.2)	5 (2.9)		24 (11.5)	0 (0.0)	
Colonic ischemia	21 (3.9)	21 (5.8)	0 (0.0)		21 (10.1)	0 (0.0)	
Traumatism/Iatrogenic	19 (3.6)	18 (5.0)	1 (0.6)		17 (8.3)	2 (0.6)	
Inflammatory bowel disease	3 (0.6)	2 (0.6)	1 (0.6)		3 (1.4)	0 (0.0)	
Tumour stage							
Benign	0 (0.0)	0 (0.0)	0 (0.0)	*0.00*	208 (100.0)	0 (0.0)	*N.A.*
I	30 (9.2)	14 (8.2)	16 (10.3)		0 (0.0)	30 (9.2)	
II	97 (29.8)	47 (27.7)	50 (32.3)		0 (0.0)	97 (29.8)	
III	106 (32.6)	52 (30.6)	54 (34.8)		0 (0.0)	106 (32.6)	
IV	92 (28.4)	57 (33.5)	35 (22.6)		0 (0.0)	92 (28.3)	
Intestinal restoration							
Yes	110 (20.6)	99 (27.3)	11 (6.5)	*0.00*	59 (28.4)	51 (15.7)	*0.01*
No	423 (79.4)	264 (72.7)	159 (93.5)		149 (71.6)	274 (84.3)	

BMI: Body Mass Index; ASA: American Society of Anaesthesiologists; N.A.: Not Applicable.
p-values indicate statistical significance based on the χ^2 test or Fisher's exact test.

cardiopulmonary complications were more prevalent in the patients with benign disease than in those with malignant disease (42.3% vs. 29.2%).

From the first procedure up to the time of data analysis 360 patients had died either during the postoperative period or during the follow-up, 104 of them during the first 30 days after surgery. Mortality rate was higher in the patients who underwent elective HP (75.9%) and those with malignant disease (72.9%).

The most frequent cause of death along the follow-up period was unrelated to the process (35.3%) or due to oncologic progression (32.5%). During the immediate postoperative period the causes of death were septic shock (18.1%), followed by medical complications (6.9%), surgical complications (4.4%) and finally, acute worsening of comorbidities (2.8%). Septic shock was the main cause of death in the emergency setting (27.3%), whereas oncologic progression (48.1%) emerged as the first determinant of death in the elective group. Accordingly, patients with benign disease died more frequently due to septic shock (35.8%) and those with malignant disease to oncologic progression (48.1%).

Characteristics of Hartmann's reversal

The second operation to restore the normal large bowel function was performed only in 110 patients who had survived the first procedure. The median hospital stay was 8 days (range: 5–43, interquartile range: 7–11). The median operative time was 180 min (range: 70–360, interquartile range: 150–240). The median time lapse between HP and reversal was 14 months (range: 1–73, interquartile range: 10–20).

In six cases (5.4%) a diverting ileostomy was associated with Hartman's reversal procedure to prevent possible complications related to the anastomosis. In one of them the rectal stump was ultra-low and in the rest was located in the middle of the sacrum. In addition, three of these patients were ASA III with a Charlson index greater than 6. All of them later underwent ileostomy closure. Of all patients initially selected for intestinal reconstruction, the procedure could not be performed in only five patients (4.5%).

Regarding complications arising after Hartmann's reversal, 52.7% of patients presented an uneventful postoperative course,

Table 2
Characteristics of Hartmann's procedure (n = 533).

	Total (*n = 533*)	Type of Surgery			Disease		
	n (%)	Urgent (*n = 363*) n (%)	Elective (*n = 170*) n (%)	*p*	Benign (*n = 208*) n (%)	Malignant (*n = 325*) n (%)	*p*
Degree of peritonitis							
Absence	284 (53.3)	125 (34.4)	159 (93.5)	*0.00*	58 (27.9)	226 (69.5)	*0.00*
Local purulent	64 (12.0)	55 (15.2)	9 (5.3)		39 (18.7)	25 (7.7)	
Diffuse purulent	98 (18.4)	98 (27.0)	0 (0.0)		63 (30.3)	35 (10.8)	
Feculent	87 (16.3)	85 (23.4)	2 (1.2)		48 (23.1)	39 (12.0)	
Indication							
Risk of anastomotic leakage	378 (70.9)	297 (81.8)	81 (47.6)	*0.00*	196 (94.2)	182 (56.0)	*0.00*
Risk of local recurrence	63 (11.8)	13 (3.6)	50 (29.4)		0 (0.0)	63 (19.4)	
Anastomotic leakage	37 (6.9)	37 (10.2)	0 (0.0)		9 (4.3)	28 (8.6)	
Carcinomatosis	23 (4.3)	13 (3.6)	10 (5.9)		0 (0.0)	23 (7.1)	
Anal incontinence	22 (4.2)	1 (0.3)	21 (12.4)		2 (1.0)	20 (6.1)	
Technical difficulty	10 (1.9)	2 (0.6)	8 (4.7)		1 (0.5)	9 (2.8)	
Perioperative transfusion							
Yes	167 (31.3)	97 (26.7)	70 (41.2)	*0.01*	53 (25.5)	114 (35.1)	*0.02*
No	366 (68.7)	266 (73.3)	100 (58.8)		155 (74.5)	211 (64.9)	
Postoperative transfusion							
Yes	201 (37.7)	144 (39.7)	57 (33.5)	*0.18*	76 (36.5)	125 (38.5)	*0.71*
No	332 (62.3)	219 (60.3)	113 (66.5)		132 (63.5)	200 (61.5)	
Surgical procedure							
Left colectomy	47 (8.7)	42 (11.6)	5 (2.9)	*0.00*	20 (9.6)	27 (8.3)	*0.00*
Sigmoid resection	367 (68.9	290 (79.9)	77 (45.3)		180 (86.5)	187 (57.5)	
Anterior rectal resection	115 (21.6)	27 (7.4)	88 (51.8)		6 (2.9)	109 (33.6)	
Segmental resection of the descending colon	4 (0.8)	4 (1.1)	0 (0.0)		2 (1.0)	2 (0.6)	
Type of surgery							
Elective	170 (31.9)	–	–	-	15 (7.2)	155 (47.7)	*0.00*
Urgent	363 (68.1)				193 (92.8)	170 (52.3)	
Type of surgeon							
Colorectal	280 (52.5)	118 (32.5)	162 (95.3)	*0.00*	66 (31.7)	214 (65.8)	*0.00*
General	253 (47.5)	245 (67.5)	8 (4.7)		142 (68.3)	111 (34.2)	
Length of rectal stump							
Over sacral promontory	7 (1.3)	7 (1.9)	0 (0.0)	*0.00*	5 (2.4)	2 (0.6)	*0.00*
Promontory	394 (73.9)	319 (87.9)	75 (44.1)		192 (92.3)	202 (62.2)	
Middle of sacrum	63 (11.9)	27 (7.4)	36 (21.2)		9 (4.3)	54 (16.6)	
Ultra-low	69 (12.9)	10 (2.8)	59 (34.7)		2 (1.0)	67 (20.6)	

p-values indicate statistical significance based on the χ^2 test or Fisher's exact test.

33.7% suffered mild type I and II complications according to Clavien-Dindo's classification and the remaining 13.6% had severe complications. 6.4% of the patients were readmitted due to some kind of complication after the restoration of intestinal continuity.

Table 4 summarizes the morbidity of Hartmann's reversal. Wound infection was the more frequent complication (27.3%). Four patients (3.6%) presented with colorectal anastomotic leakage. In one case, the patient was re-operated to repair the anastomotic defect associating a diverting loop ileostomy, which was subsequently closed. In the other three cases, the colostomy was performed again, without subsequent reconstruction: one was ruled out due to technical difficulties, another because the patient refused the intervention, and the third because the patient died in the postoperative period due to septic shock and multiple organ failure, being the only patient in this series to die in the immediate postoperative period (0.9%). These three patients, together with two patients who were ruled out due to technical difficulties during dissection of the rectal stump, make up the five patients (4.5%) who despite being recommended for intestinal continuity reconstruction could not finally undergo a successful operation. There were no differences in morbidity or mortality rates between the patients who underwent urgent HP and elective HP, neither between those with benign disease and malignant disease.

Frequency of Hartmann's procedure and reversal

Fig. 1 shows the temporal evolution of how frequently Hartmann's reversal was performed. In the Kruskal-Wallis test, significant differences were found ($p < 0.019$) between groups according to the year in which HP was performed. In order to draw clearer conclusions about differences over time and to get a more accurate picture of HP reversal trends during the time period included in this study, we divided the series into three groups of 5 years (1999–2004, 2005 to 2009 and 2010 to 2014). We found a tendency to perform fewer HPs (184, 190 and 159 respectively) and in turn a greater proportion of intestinal transit reconstructions (15.8%, 18.9% and 28.3% respectively) with significant differences in χ^2 test during the last period ($p = 0.02$).

Classification and regression–tree analysis of factors influencing the decision to restore intestinal continuity: the relative importance of each variable

From the branches of the classification trees formulated from this series we ascertained that patients aged over 69 with severe comorbidities (ASA score of III or IV) who required postoperative transfusion, had almost 0% probability of intestinal reconstruction, the lowest probability offered by the models (Fig. 2).

Table 3
Morbidity of Hartmann's procedure.

	Total (*n* = 533)	Type of Surgery			Disease		
	n (%)	Urgent (*n* = 363)	Elective (*n* = 170)	*p*	Benign (*n* = 208)	Malignant (*n* = 325)	*p*
		n (%)	n (%)		n (%)	n (%)	
Clavien-Dindo classification							
None	136 (25.5)	71 (19.6)	65 (38.3)	*0.00*	44 (21.2)	92 (28.3)	*0.09*
I	28 (5.3)	15 (4.1)	13 (7.6)		9 (4.3)	19 (5.8)	
II	106 (19.9)	68 (18.7)	38 (22.4)		42 (20.2)	64 (19.8)	
III A	31 (5.8)	26 (7.2)	5 (2.9)		14 (6.7)	17 (5.2)	
III B	42 (7.9)	29 (8.0)	13 (7.6)		12 (5.8)	30 (9.2)	
IV A	44 (8.3)	35 (9.6)	9 (5.3)		17 (8.2)	27 (8.3)	
IV B	34 (6.3)	25 (6.9)	9 (5.3)		13 (6.2)	21 (6.5)	
V	112 (21.0)	94 (25.9)	18 (10.6)		57 (27.4)	55 (16.9)	
Morbidity							
Cardiopulmonary	183 (34.3)	149 (41.0)	34 (20.0)	*0.01*	88 (42.3)	95 (29.2)	*0.01*
Urinary	54 (10.1)	38 (10.5)	16 (9.4)	*0.76*	19 (9.1)	35 (10.8)	*0.66*
Intrabdominal abscess	51 (9.6)	37 (10.2)	14 (8.2)	*0.53*	20 (9.6)	31 (9.5)	*0.54*
Bleeding	23 (4.3)	14 (3.9)	9 (5.3)	*0.49*	5 (2.4)	18 (5.5)	*0.12*
Ileus	23 (4.3)	12 (3.3)	11 (6.5)	*0.11*	8 (3.8)	15 (4.6)	*0.83*
Stoma complications	36 (6.8)	32 (8.8)	4 (2.4)	*0.00*	16 (7.7)	20 (6.2)	*0.48*
Wound infection	90 (16.9)	63 (17.4)	27 (15.9)	*0.71*	35 (16.8)	55 (16.9)	*0.54*
Wound dehiscence	22 (4.1)	21 (5.8)	1 (0.6)	*0.01*	12 (5.8)	10 (3.1)	*0.18*
Others	35 (6.6)	18 (5.0)	17 (10.0)	*0.04*	8 (3.8)	27 (8.3)	*0.05*
Mortality							
Yes	360 (67.5)	231 (63.6)	129 (75.9)	*0.01*	123 (59.1)	237 (72.9)	*0.01*
No	173 (32.5)	132 (36.4)	41 (24.1)		85 (40.9)	88 (27.1)	
Postoperative death							
Immediate (≤30 days)	104 (19.5)	87 (89.7)	17 (89.5)	*0.62*	53 (89.8)	51 (89.5)	*0.59*
Late (>30 days)	12 (2.2)	10 (10.3)	2 (10.5)		6 (10.2)	6 (10.5)	
Cause of death							
Septic shock	65 (18.1)	63 (27.3)	2 (1.5)	*0.01*	44 (35.8)	21 (8.9)	*0.01*
Surgical complications	16 (4.4)	11 (4.7)	5 (3.9)		3 (2.4)	13 (5.5)	
Medical complications	25 (6.9)	17 (7.4)	8 (6.2)		7 (5.7)	18 (7.6)	
Worsening of comorbidities	10 (2.8)	6 (2.6)	4 (3.1)		5 (4.1)	5 (2.1)	
Oncologic progression	117 (32.5)	55 (23.8)	62 (48.1)		0 (0.0)	114 (48.1)	
Unrelated to the process	127 (35.3)	79 (34.2)	48 (37.2)		64 (52.0)	66 (27.8)	
Readmission							
Yes	65 (12.2)	47 (12.9)	18 (10.6)	*0.48*	17 (8.2)	48 (14.8)	*0.03*
No	468 (87.8)	316 (87,1)	152 (89.4)		191 (91.8)	277 (85.2)	

p-values indicate statistical significance based on the χ^2 test or Fisher's exact test.

In the group of benign disease, patients aged over 69 with ASA score III-IV presenting purulent or feculent peritonitis, also had almost 0% probability of Hartmann's reversal (Fig. 3). In the group of malignant disease, those patients over 69 years and with Charlson index higher than 6, had 4.8% probability of intestinal restoration (Fig. 4).

In contrast, patients with a benign disease aged under 69 years, presenting with low comorbidity (ASA score of I or II), had an 84.4% probability of undergoing intestinal continuity reconstruction (the highest value predicted by the models) (Fig. 3).

Fig. 5 depicts the relative weighting of the different variables included in the global classification tree model: the most important predictors of intestinal restoration were a Charlson index lower than 6 (100%), age lower than 69 (78,6%) and ASA stage I or II (59,4%).

Discussion

Most patients included in this study were operated on urgently (68.1%), mainly due to sigmoid or rectal cancer or complicated diverticulitis. HP is a surgical resource drawn on frequently by any surgeon in the emergency setting because it is feasible, safe and easy to perform, especially in the acutely ill patient.[13]

When analysing the incidence of postoperative complications of HP, overall morbidity was 53.5%, similar to studies by Dumont et al. (2005) who reported 51% and by Aydin et al. (2006) with 50.4%.[5,6] The systematic review conducted by Toro et al. (2012) that included 586 diverticulitis patients undergoing HP, also found an incidence rate of 49.5% for global complications.[3] However, other groups documented lower rates, ranging between 20% and 40%.[4,7,10,11] In our series, complications were high, probably because many of the patients had severe comorbidities, advanced age and a critical clinical situation.

Cardiopulmonary complications were the most frequent medical complications (34.3%), as in many other series.[5,7] However, other groups reported lower rates.[6,9,10,12] Some authors only included patients with diverticular disease, and this may affect the prevalence of complications. In our series the patients with benign disease presented cardiopulmonary complications more frequently than those with malignant disease. Patients with benign disease are prone to suffer medical complications because were commonly operated under a septic condition in an emergency setting.

Stoma-related complications were found in 6.8% of patients, similar to those reported by Dumont et al. (2005),[5] but lower than those in the systematic review by Abbas et al. (2007) or Fleming et al. (2009), which rose up to 12%.[4,12] This event was usually not included in studies on HP morbidity.

Mortality in the immediate postoperative period (≤30 days) was 19.5% and was mainly due to septic shock (62.5%). In the systematic review of the literature on the surgical treatment of patients with complicated diverticulitis published by Abbas et al. (2007) which examined 18 studies, they observed a 30-day mortality of HP of 33.4%.[4] Other authors have also found high mortality rates in the

Table 4
Morbidity of Hartmann's reversal.

	Total (*n = 110*)	Type of Surgery			Disease		
	n (%)	Urgent (*n = 99*) n (%)	Elective (*n = 11*) n (%)	*p*	Benign (*n = 59*) n (%)	Malignant (*n = 51*) n (%)	*P*
Clavien-Dindo classification							
None	58 (52.7)	52 (52.5)	6 (54.5)	*0.98*	30 (50.8)	28 (54.9)	*0.27*
I	6 (5.5)	5 (5.0)	1 (9.1)		2 (3.4)	4 (7.8)	
II	31 (28.2)	28 (28.3)	3 (27.3)		19 (32.2)	12 (23.5)	
III A	1 (0.9)	1 (1.0)	0 (0.0)		0 (0.0)	1 (2.0)	
III B	8 (7.3)	7 (7.1)	1 (9.1)		6 (10.2)	2 (3.9)	
IV A	5 (4.5)	5 (5.1)	0 (0.0)		1 (1.7)	4 (7.9)	
IV B	0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
V	1 (0.9)	1 (1.0)	0 (0.0)		1 (1.7)	0 (0.0)	
Morbidity							
Cardiac	3 (2.7)	1 (1.1)	2 (8.7)	*0.11*	2 (3.4)	1 (2.0)	*0.55*
Pulmonary	4 (3.6)	3 (3.4)	1 (4.3)	*0.61*	2 (3.4)	2 (3.9)	*0.63*
Urinary	2 (1.8)	2 (2.3)	0 (0.0)	*0.62*	1 (1.7)	1 (2.0)	*0.71*
Intrabdominal abscess	2 (1.8)	2 (2.3)	0 (0.0)	*0.62*	1 (1.7)	1 (2.0)	*0.71*
Bleeding	3 (2.7)	3 (3.4)	0 (0.0)	*0.49*	2 (3.4)	1 (2.0)	*0.55*
Ileus	4 (3.6)	3 (3.4)	1 (4.3)	*0.61*	3 (5.1)	1 (2.0)	*0.62*
Wound infection	30 (27.3)	23 (26.4)	7 (30.4)	*0.79*	16 (27.1)	14 (27.5)	*0.57*
Wound dehiscence	0 (0.0)	0 (0.0)	0 (0.0)	*0.71*	0 (0.0)	0 (0.0)	*0.71*
Anastomotic leakage	4 (3.6)	3 (3.4)	1 (4.3)	*0.61*	3 (5.1)	1 (2.0)	*0.62*
Others	4 (3.6)	3 (3.4)	1 (4.3)	*0.61*	3 (5.1)	1 (2.0)	*0.62*
Mortality							
Yes	18 (16.4)	16 (16.2)	2 (18.2)	*0.57*	6 (10.2)	12 (23.5)	*0.73*
No	92 (83.6)	83 (83.8)	9 (81.8)		53 (89.8)	39 (76.5)	
Readmission							
Yes	7 (6.4)	6 (6.1)	1 (9.1)	*0.53*	5 (8.5)	2 (3.9)	*0.45*
No	103 (93.6)	93 (93.9)	10 (90.9)		54 (91.5)	49 (96.1)	

p-values indicate statistical significance based on the χ^2 test or Fisher's exact test.

immediate postoperative period, ranging between 20% and 34%.[3,9,12,13,17] However, other groups had a lower early global mortality rate, between 2.1% obtained by Vaid et al. (2011) and 14% by Dumont et al. (2005).[1,5,7,10,12,33] The main causes of death were heart failure, renal failure and respiratory failure, as expected in the critical ill patient.

In our series, overall morbidity after Hartmann's reversal was 47.3%, similar to that published by other authors, ranging between 37% and 55%.[1,13,16–18,21–23,28] Although most of these complications were minor, this high morbidity reflects the difficulty of the intestinal reconstruction procedure. However, some systematic reviews have revealed that patients who were laparoscopically reconstructed had lower morbidity rates, between 12.2% and 16.5%.[25,26,34]

The most frequent complication was wound infection that occurred in 27.3% of cases, somewhat more frequently than usual in colorectal surgery. High rates of wound infection reaching levels of around 25% have been also reported in other series.[1,13,28] However, the majority of studies showed much lower rates, between 6% and 8%.[17,18,23,25,34–37] In our setting, all the anastomoses were performed by colorectal surgeons. We found an anastomotic leakage rate of 3.6%, lower than other authors[1,17,20,22,23,26,28] who reported 16%, and the only patient who died in our series was as a result of this complication. A protective ileostomy was not systematically

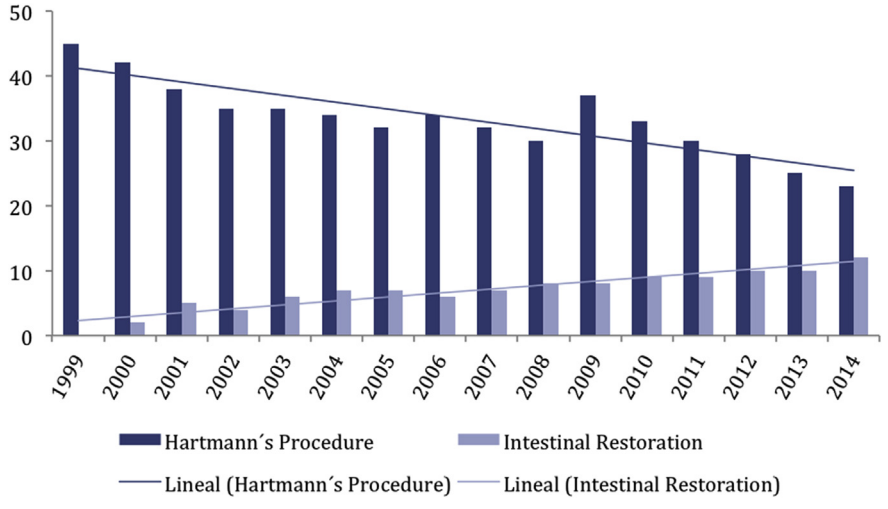

Fig. 1. Frequency of Hartmann's procedure and of Hartmann's reversal.

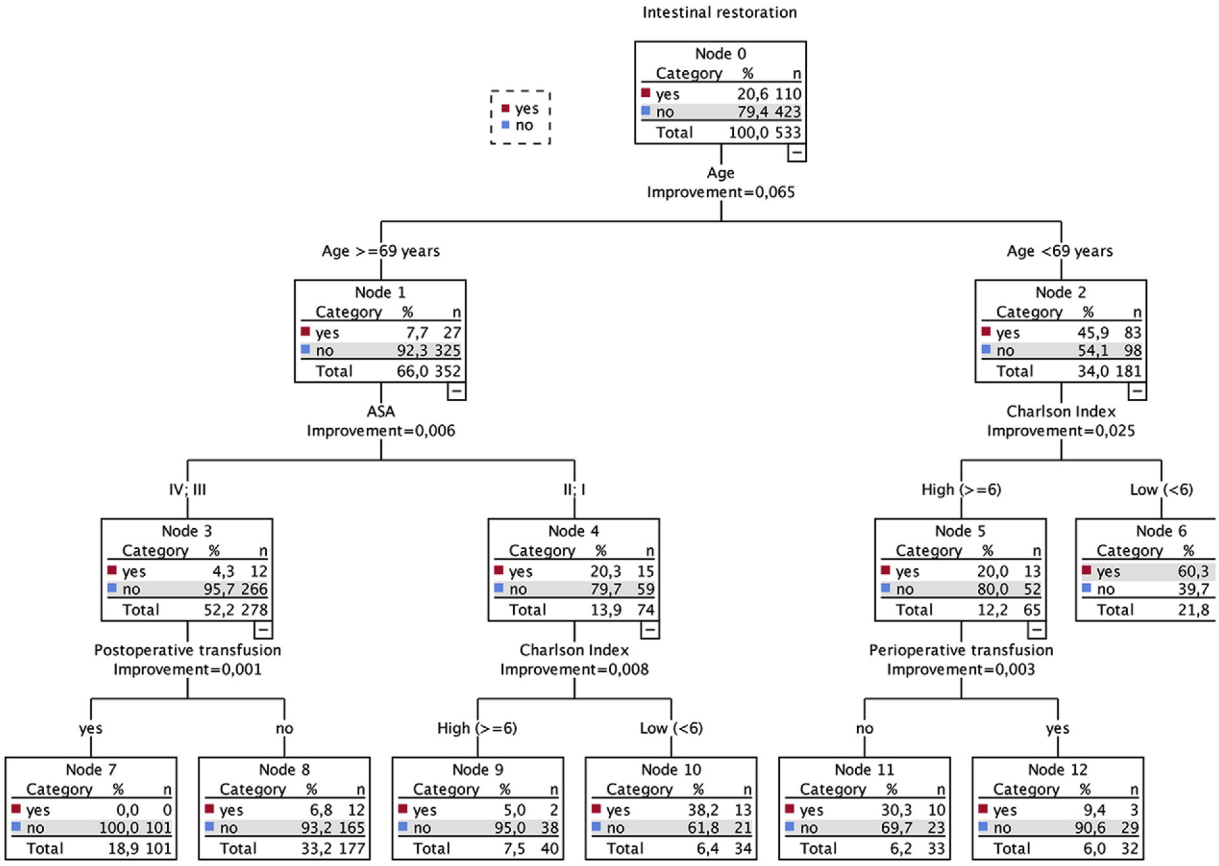

Fig. 2. Classification and regression tree of factors influencing the decision to restore intestinal continuity including all the patients.

associated, only being performed in 6 patients (5.4%) with ultra-low anastomosis and high comorbidity. All patients subsequently underwent ileostomy reversal. Diverting ileostomies have been performed in the literature between 3% and 26% of cases of intestinal reconstruction and approximately 90% can be reversed later.[18,29,31,35,36]

Mortality was 0.9%, almost equal to that shown by the majority of studies,[5,12,13,16,17,25,26,28,34,36–38] although some authors have reported higher rates, up to 5%.[1,22,23]

A trend to perform less HP has been found over the 16 years of the study. Recently has been demonstrated that in patients with some kind of peritonitis of the left colon the primary anastomosis is at least as safe as a HP. Consequently, the usefulness of HP has been restricted at present in the emergency setting.[2–4,19,33,39,40] Reconstruction of intestinal continuity was performed in 27.2% of patients who survived HP. Other Spanish series, such as Roque-Castellano et al. (2007) found similar results with a reconstruction rate of 25.9%,[13] although Roig et al. (2011) showed a somewhat higher rate, of 35.2%.[1] However, most authors have reported higher rates of intestinal restoration, between 30% and 69%.[17,18,21–24,28–31]

Frequency of reversal may vary depending on many factors, such as age, comorbidities, surgical or anaesthetic risks, anal incontinence and the patient's preferences. The rate of intestinal reconstruction in our series was relatively low, probably due to advanced age, high comorbidity of the patients and also the inclusion of patients with malignant diseases. Studies including mainly patients with benign pathologies have a higher reconstruction rate (31–85%) than those with malignant (4–53%).[1,13,20,23,27,31,36]

Of all patients initially selected for intestinal reconstruction, the procedure could not be performed in only five patients (4.5%), in accordance with other studies.[1,17,37,38] Failure in Hartmann's reversal have been communicated at higher rates reaching up to 10.5%. Firm adhesions of the rectal stump, massive pelvic bleeding and previous radiotherapy were the main factors for the lack of intestinal reconstruction.[26,28,36]

Hartmann's reversal has been increasingly performed in our hospital in the most recent years of the study. Patients who years ago would typically have been ruled out for reoperation due to age or multiple comorbidities, at present are more frequently included in a protocol of intestinal restoration. Additionally, an increase in current life expectancy together with a greater awareness of quality of life makes Hartmann's reversal an appealing option.

There is controversy in the literature about the influence of delaying reconstruction on the appearance of postoperative complications. While some groups observed less morbidity and mortality if the reversal was performed 6 months after HP, others argued that an increase in the waiting time for reconstruction is independently associated with complications after intestinal restoration, which could reach up to 44% in those patients reconstructed more than 9 months after the initial procedure.[12,24] In our series, the median delay was 14 months. The majority of studies have shorter waiting times than ours, ranging from 3 to 12 months.[11,16,17,20,27,36] Longer periods between the first and second intervention may hinder intestinal reconstruction because the dissection of the rectal stump may be more complex due to the atrophy and retraction. However in our series, no relationship was observed between delay and postoperative complications.

To the best of our knowledge, this current study is unique in its use of a classification tree to obtain a visual composition of the relationship between the variables that influenced intestinal

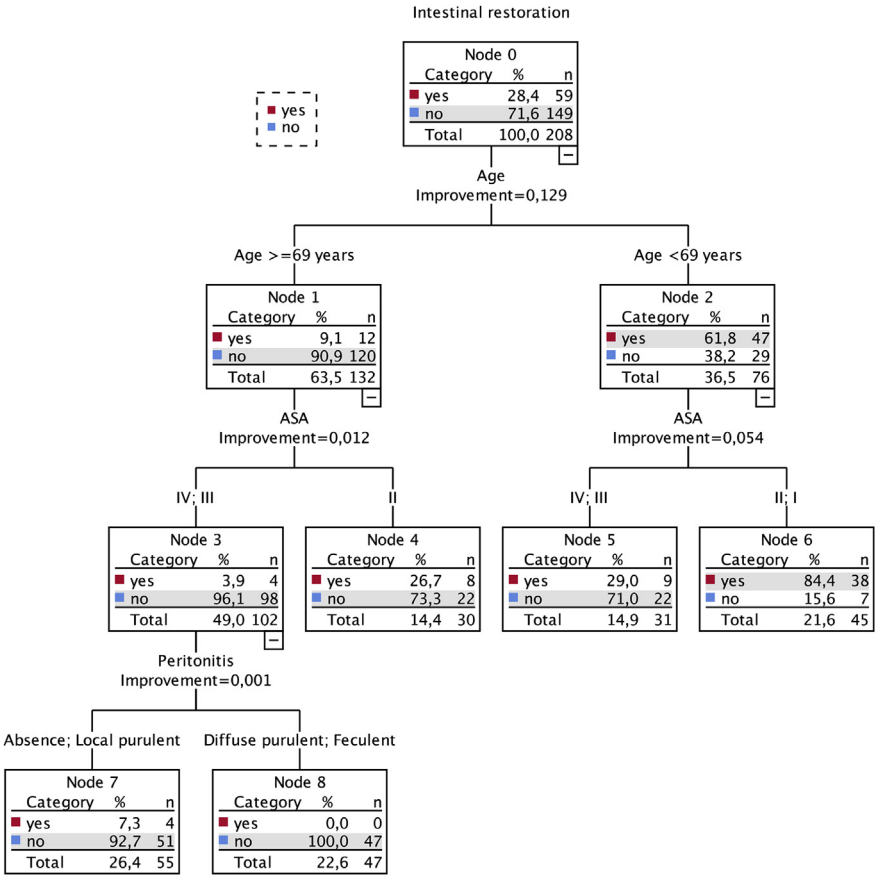

Fig. 3. Classification and regression tree of factors influencing the decision to restore intestinal continuity for those patients with benign disease.

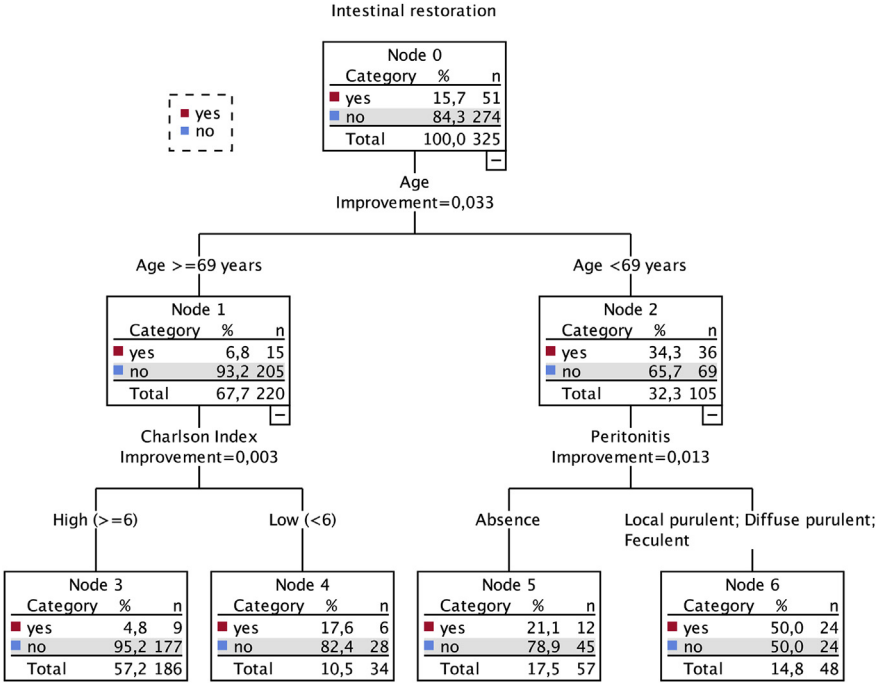

Fig. 4. Classification and regression tree of factors influencing the decision to restore intestinal continuity for those patients with malignant disease.

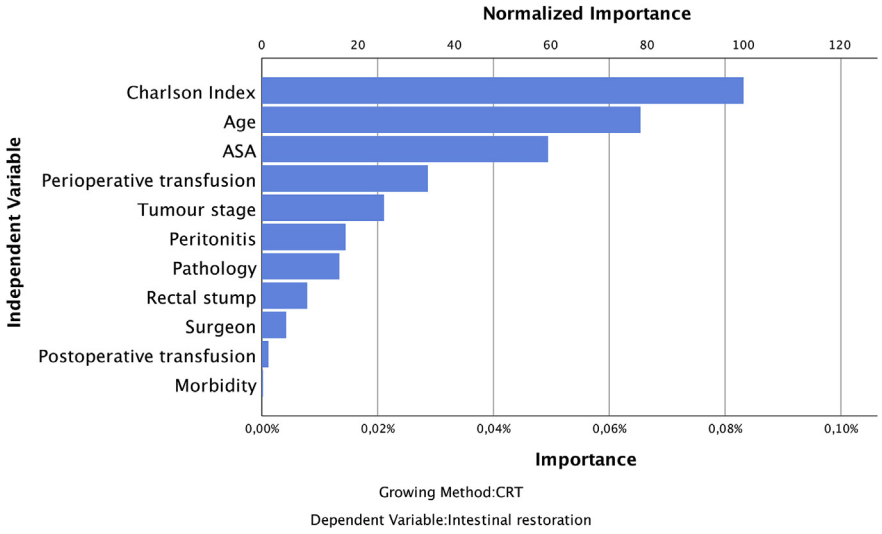

Fig. 5. Importance of the variables included in the classification tree model.

reconstruction in our setting. In our model, age was the variable setting the first classification node. Age below 69 years was a decisive factor for restitution of intestinal continuity. In concordance, Hodgson et al. (2016) found age under 70 years as the only significant predictor of intestinal reconstruction.[37] Other authors also found age to be a predictive factor for reconstruction after HP, but in the statistical analysis they did not identify a cut-off point for differences in probability. In most series, patients aged over 73 were less likely to undergo HP reversal surgery, whereas there were higher rates of intestinal continuity restoration in patients aged under 60.[10,11,13,28,30]

The Charlson index was the independent factor with the most explanatory importance in our classification-tree model. Accordingly, other authors also stated that comorbidities were independent predictors of bowel continuity restoration.[5,10,11,13,28]

Intestinal reconstruction is more likely to be indicated in patients with ASA score I or II. Riansuwan et al. (2009) developed a score at the Cleveland Clinic to predict the probability of Hartmann's reversal based on the independent predictive factors obtained in the multivariate analysis (age, ASA score, pulmonary comorbidity, preoperative transfusion, perforation and anticoagulant intake). The lower the score, the higher the likelihood of intestinal reconstruction.[11] Subsequently, Vaid et al. (2011) validated this score in a centre in Pennsylvania and concluded that it was the only factor independently associated with intestinal reconstruction.[10] In the present study, age under 69 years associated with a low rate of comorbidities, quantified using the Charlson index or the ASA score, were the most important factors in the eventual decision to restore intestinal continuity.

This study identifies well-known problems related to HP and reversal, and reveals the clinical reality facing many general surgeons in their usual practice. Additionally, it shows that in many cases HP is definitive and that restoring intestinal continuity involves considerable morbidity, although with low mortality rates. Therefore, resection with primary anastomosis should be seriously considered as an alternative provided the patient is hemodynamically stable and technical and surgical conditions are available. However, sometimes the priority of saving patient's life relegates all other issues to the background.

Nevertheless, the study has some weaknesses because of its observational and retrospective nature. During the period of the study some changes in the surgical indications for urgent HP have been introduced. Furthermore, urgent surgical indications can vary depending on the experience of the surgeon, therefore a selection bias could arise among those patients.

Given the low frequency of intestinal reconstruction, lag times and related morbidity and mortality, physicians should carefully weigh up and justify the decision to perform HP, providing the patient with the necessary information about different surgical options and risks.

In conclusion, HP is associated with high morbidity and mortality rates, but subsequent restoration of intestinal continuity entails minor but frequent morbidity as well as low mortality. Recent years have witnessed a clear trend to perform less HP and more reconstructions of intestinal continuity. Age and comorbidities are of paramount importance in the decision to restore intestinal continuity in these patients.

Conflicts of interest

The authors have no conflict of interest to report.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjsurg.2019.02.025.

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