

# Comparative Study between Proximal and Distal Ligation of Splenic Artery during Open Splenectomy and its Effect on Intraoperative and Postoperative Complications

Mohamed Abdelsattar Abdelhamid, MD;<sup>1</sup> Mohammed Waeil Mohammed, MSc;<sup>2</sup> Ahmed ElSayed Mourad, MD;<sup>2</sup> Mahmoud Talaat Rayan, MD<sup>1</sup>

<sup>1</sup>Department of General and Hepatobiliary Surgery, Faculty of Medicine, Ain Shams University, Egypt

<sup>2</sup>Department of General Surgery, Faculty of Medicine, Ain Shams University, Egypt

**Introduction:** Splenectomy, the surgical removal of the spleen, is performed for various hematologic, infectious, inflammatory, neoplastic, and traumatic conditions. Understanding the anatomy and physiology of the spleen, particularly the course of the splenic artery that supplies the spleen is crucial for surgical planning. The choice between proximal and distal ligation of the splenic artery during open splenectomy has been a subject of clinical investigation.

**Aim of work:** This study aims to assess the outcomes and effects of proximal versus distal ligation of the splenic artery on intraoperative and postoperative complications during open splenectomy.

**Patient and methods:** A retrospective study was conducted at Ain Shams University Hospitals between January and August 2024 to evaluate the effects of proximal versus distal ligation of the splenic artery on intraoperative and postoperative outcomes. The study included 50 patients (29 in distal ligation group, 21 in proximal group).

**Results:** The study's key findings revealed that the proximal ligation group had a statistically significant reduction in operative time ( $P=0.023$ ) and shorter hospital stays ( $P<0.05$ ) compared to the distal ligation group. Additionally, the distal ligation group experienced higher postoperative wound infection rates ( $P=0.001$ ) and an increased risk of postoperative pancreatic fistula (POPF) occurrence ( $P<0.05$ ). No significant differences were observed between the groups regarding intraoperative hemorrhage ( $P=0.114$ ) or postoperative hemorrhage ( $P=0.235$ ).

**Conclusion:** Our findings suggest that proximal splenic artery ligation is associated with shorter operative time and lower wound infection rates without increasing intraoperative or postoperative complications. While the risk of POPF was higher in the distal ligation group.

**Key words:** Open splenectomy, splenic artery, pancreatic fistula, operative time.

## Introduction

Splenectomy, the surgical removal of the spleen, is performed for a variety of indications. A comprehensive understanding of the spleen's anatomy and physiology is crucial before undertaking the procedure. Depending on the patient's condition and diagnosis, splenectomy can be performed using open, laparoscopic, or robotic techniques.<sup>1</sup>

Splenectomy is performed in various clinical situations, including benign and malignant conditions, as well as for anatomical abnormalities and traumatic injuries.<sup>2,3</sup>

The splenic artery, a branch of the celiac trunk, is the main arterial supply to the spleen. The splenic artery courses along the upper border of the body and tail of the pancreas. The splenic artery then bifurcates to the short gastric and the left gastroepiploic artery, which supplies the stomach prior to entering the splenic hilum.<sup>4</sup>

The splenic artery can be ligated using either an anterior or posterior approach. In the anterior approach, access to the lesser sac is obtained, allowing identification of the splenic artery along the superior border of the pancreatic body. The artery is then ligated, with ligatures placed as distally as possible. In the posterior approach, the spleen is mobilized and lifted outside the peritoneal cavity,

followed by dissection and ligation of the splenic artery near the hilum.<sup>4</sup>

During surgery, complications such as bleeding, trauma to the pancreatic tail, stomach, splenic flexure of the colon, left hemidiaphragm, left suprarenal gland, and upper pole of the left kidney may occur and must be promptly managed during the same procedure. In the early postoperative period, potential complications include postoperative bleeding, subphrenic abscess, pulmonary atelectasis, bronchopneumonia, and left pleural extravasation.<sup>5</sup>

The most severe complication of splenectomy is overwhelming post-splenectomy infection (OPSI), which begins with a generalized, non-specific flu-like illness and rapidly progresses to fulminant septic shock within 24–48 hours of onset.<sup>6</sup>

Intra-abdominal hemorrhage can be fatal, with delayed or inadequate treatment having a high mortality rate. The complications following splenectomy, including pneumonia, pancreatitis, gastric fistula, gastric flatulence, and thrombocytosis, in patients with postoperative hemorrhage were significantly higher than those without hemorrhage.<sup>7</sup>

Postoperative pancreatic fistula (POPF) is a significant complication following splenectomy, with an incidence of 4.5%. The spleen's close anatomical relationship with the pancreatic tail increases the

risk of pancreatic injury during mobilization. POPF occurs due to leakage from the damaged pancreatic parenchyma.<sup>8</sup>

### Aim of work

This study aims to assess the outcomes and effects of proximal versus distal ligation of the splenic artery on intraoperative and postoperative complications during open splenectomy.

### Patients and methods

A retrospective cohort study was conducted at General surgery department, Ain Shams University Hospitals in the period between April 2024 to august 2024, including 50 patients who underwent open splenectomy for different causes, 29 patients had distal splenic artery ligation, and 21 patients had proximal splenic artery ligation. All patients had complete records of management. The study had the approval of Research Ethical Committee (REC) of the Department of Surgery, Ain Shams University Faculty of Medicine (IRB 00006379), and all procedures were performed in accordance with the ethical standards laid down in the Declaration of Helsinki and its later amendments. Written informed consent was obtained from all participants. Inclusion Criteria: 1) patients who underwent elective open splenectomy. 2) age >18 years. Exclusion Criteria: 1) Patients undergoing laparoscopic splenectomy. 2) Patients undergoing partial splenectomy. (3) Previous upper abdominal surgery. 4) Bleeding disorder at time of surgery. 5) Traumatic Splenectomy.

Data was collected from patient records and interviews, including age, sex, Indications for surgery, operative findings, ligation site of splenic artery, intra-operative blood loss, operative time, hospital stay and postoperative complication if happened.

Data were analyzed using SOFA statistics Version 1.5.4, Paton-Simpson & Associates Ltd, Auckland, New Zealand. Continuous variables are presented

as mean  $\pm$  standard deviation (SD) or median (Interquartile range [IQR]) depending on normality. Categorical variables are expressed as frequencies and percentages

### Results

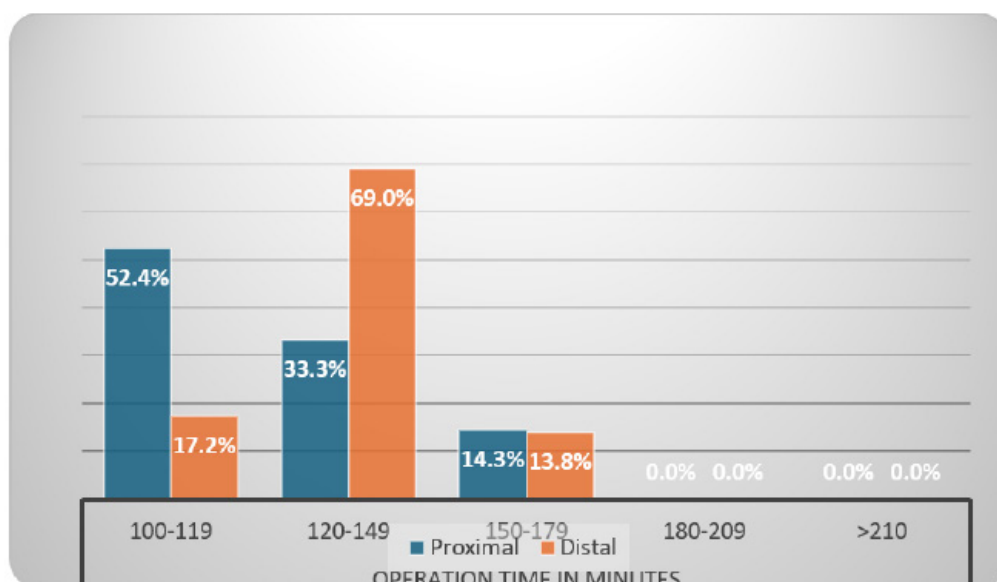
This retrospective study evaluates the outcomes and effects of proximal versus distal splenic artery ligation on intraoperative and postoperative complications during open splenectomy, the study included 50 patients aged 20 to 54 years, with demographic details presented in **(Table 1)**.

The previous table shows that there was no statistically significant difference between proximal and distal groups regarding age and sex distribution of the studied patients with p-value=0.168 and 0.598.

Statistical analysis revealed a significant difference in operative time based on the site of ligation, with proximal ligation associated with shorter operative time ( $P=0.023$ ), with 52.4% of cases taking 100-119 minutes in proximal ligation and 69% of patients taking 120-149 minutes in distal ligation ( $P$  value 0.023) **(Fig. 1)**. However, no significant differences were observed concerning intraoperative hemorrhage or blood transfusion needs ( $P=0.114$  and  $p=0.055$ , respectively).

The findings demonstrate significant differences in hospitalization duration, the incidence of postoperative pancreatic fistula, drainage volume, and wound infection rates between the two groups. The levels of serum amylase on postoperative day one were also significantly different (Proximal: range 55-92; distal: range 47-272,  $p=0.032$ ).

Notably, there were no significant differences in postoperative hemorrhage or re-exploration rates, with one instance of re-exploration in the proximal ligation group due to hemorrhage. Furthermore, three patients in the distal ligation group experienced pancreatic leakages managed conservatively starting from the second postoperative day.



**Fig 1: Comparison between patients with proximal and distal sites of ligation of splenic artery regarding operation time in minutes.**

**Table 1: Comparison of demographics two groups Demographic data of two groups**

		Site of Ligation of Splenic Artery		Test value	P-value	Sig.
		Proximal	Distal			
		No.= 21	No.= 29			
Age	20-29	15 (71.4%)	12 (41.4%)	5.049*	0.168	NS
	30-39	3 (14.3%)	9 (31%)			
	40-49	2 (9.5%)	3 (10.3%)			
	>50	1 (4.8%)	5 (17.2%)			
Sex	Male	10 (47.6%)	16 (55.2%)	0.278*	0.598	NS
	Female	11 (52.4%)	13 (44.8%)			

**Table 2: Comparison between patients with proximal and distal sites of ligation of splenic artery regarding intraoperative parameters**

		Site of Ligation of Splenic Artery		Test value	P-value	Sig.
		Proximal	Distal			
		No.= 21	No.= 29			
<b>Operation Time in Minutes</b>	100-119	11 (52.4%)	5 (17.2%)	7.566*	0.023	S
	120-149	7 (33.3%)	20 (69%)			
	150-179	3 (14.3%)	4 (13.8%)			
	180-209	0 (0%)	0 (0%)			
	>210	0 (0%)	0 (0%)			
<b>Intraoperative Hemorrhage</b>	200-300 ml	7 (33.3%)	17 (58.6%)	4.336*	0.114	NS
	300-400 ml	9 (42.9%)	10 (34.5%)			
	400-500 ml	5 (23.8%)	2 (6.9%)			
	>500 ml	0 (0%)	0 (0%)			
<b>Intraoperative Blood Transfusion</b>	1 PRBCs	10 (47.6%)	13 (44.8%)	5.783*	0.055	NS
	2 PRBCs	5 (23.8%)	1 (3.4%)			
	No	6 (28.6%)	15 (51.7%)			

P-value > 0.05: Non-significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant.

\*: Chi-square test.

**Table 3: Comparison between patients with proximal and distal sites of ligation of splenic artery regarding postoperative parameters**

		Site of ligation of splenic artery		Test value	P-value	Sig.
		Proximal	Distal			
		No.= 21	No.= 29			
<b>Hospital stay in days</b>	2 Days	0 (0%)	0 (0%)	5.155*	0.05	S
	3 Days	5 (23%)	2 (6.9%)			
	4 Days	15 (71%)	9 (31%)			
	5 Days	0 (0%)	8 (27.5%)			
	6 Days	2 (9%)	8 (27.5%)			
	More than 6 days	0	2 (6.9)			
<b>Postoperative hemorrhage</b>	Yes	1 (4.8%)	0 (0%)	1.409*	0.235	NS
	No	20 (95.2%)	29 (100%)			
<b>Postoperative pancreatic fistula</b>	Yes	0 (0%)	3 (10.34%)	1.509*	< 0.05	S
	No	21 (100%)	25 (89.6%)			
<b>Amount of drain</b>	<50ml	0 (0%)	0 (0%)	3.563*	< 0.05	S
	50-99ml	13 (61.9%)	20 (69%)			
	100-199ml	3 (14.3%)	0 (0 %)			
	200-299ml	4 (19%)	2 (6.9%)			
	>300ml	1 (4.8%)	7 (24.1%)			
<b>First day postoperative serum amylase</b>	Median (IQR)	77 (63 - 81)	80 (69 - 88)	-2.144#	0.032	S
	Range	55 – 92	47 – 272			
<b>Postoperative portal vein thrombosis</b>	Yes	0 (0%)	0 (0%)	–	–	–
	No	21 (100%)	29 (100%)			
<b>Postoperative wound infection</b>	Yes	1 (4.8%)	14 (48.3%)	10.982*	0.001	HS
	No	20 (95.2%)	15 (51.7%)			
<b>Re-exploration</b>	Yes	1 (4.8%)	0 (0%)	1.409*	0.235	NS
	No	20 (95.2%)	29 (100%)			

P-value > 0.05: Non-significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant.

\*: Chi-square test; •: Independent t-test; #: Mann-Whitney test.

## Discussion

Splenectomy is indicated in several clinical scenarios, including benign and malignant processes, as well as for anatomical reasons and traumatic injuries.<sup>2,3</sup> Depending on the underlying condition and diagnosis, splenectomy can be performed using open, laparoscopic, or robotic-assisted techniques.<sup>9</sup>

Open splenectomy remains a crucial surgical procedure, particularly in cases of splenic trauma or when laparoscopic techniques are not feasible.<sup>10</sup> A key step in this procedure is the ligation of the splenic artery, which can be performed proximally near its origin or distally at the splenic hilum. This study aimed to evaluate the intraoperative and postoperative outcomes and complications associated with each approach.

Our findings indicate no significant differences in preoperative demographics or comorbidities between the proximal and distal ligation groups. Operative time was significantly shorter in the proximal ligation group, likely due to easier access

to the artery, 52.4% of cases in the proximal group taking 100-119 minutes with only 17.2% of cases taking the same time in the distal group. Also, 33.3% of cases in the proximal group took 120-149 minutes while 69% of cases in the distal group took the same time (P value=0.023). Intraoperative and postoperative hemorrhage rates did not differ significantly, although one patient in the proximal group (4.8% of cases with proximal ligation) with none in the distal group, required re-exploration with no definite source of bleeding only oozing from splenic bed which controlled with diathermy.

This can be compared with Ahmed I. et al. (2017)<sup>12</sup> who reported lower incidence of postoperative hemorrhage, being 2 out of 112 patients (1.97%). Both patients were reoperated, and no definite bleeding source was identified, only oozing in the splenic bed was found. Unfortunately, one patient died after re-exploration. In contrast, Taner et al. (2013)<sup>11</sup> reported that the incidence of hemorrhage in splenectomy was 9%.<sup>12</sup> A higher incidence in their study may be attributed to the larger sample size

compared to our study or variation in preoperative spleen size.

The incidence of postoperative pancreatic fistula (POPF) was higher in the distal ligation group, with three patients (10.34%) developing POPF, while no cases were observed in the proximal ligation group. According to the 2016 definition by the International Study Group on Pancreatic Surgery (ISGPS), POPF is characterized by an amylase level in abdominal drainage fluid at least three times the laboratory's normal value on or after postoperative day 3, significantly impacting clinical outcomes (POPF grades B & C.<sup>13</sup> An isolated elevation of amylase without clinical consequences is classified as a biochemical leak (BL), previously referred to as grade A POPF.<sup>13</sup>

Among the three affected patients, one had only biochemical leakage (3.4%), while the other two developed grade B POPF (6.9%). The first patient presented with a pancreatic fistula on postoperative day 3, with an initial serum amylase level of 272 U/L and an elevated amylase level in the drain fluid on day 3, accompanied by a drain output of 200 ml/day. This patient was managed conservatively without requiring re-exploration. A contrast-enhanced CT scan of the abdomen and pelvis revealed a collection in the splenic bed. Management included total parenteral nutrition (TPN) and octreotide therapy. A follow-up CT scan two weeks later showed a reduction in collection size and a decreased drain output of 50 ml/day. The drain was subsequently removed, and the patient was discharged one month postoperatively with no drain output and normalized amylase levels in both serum and drain fluid.

The second patient developed a late-onset pancreatic fistula, with a first-day postoperative amylase level of 136 U/L. This patient was discharged on postoperative day 4 after drain removal, with no recorded output, but returned two days later with abdominal pain. A pelvic ultrasound revealed a localized collection near the splenic bed and pancreatic tail. A contrast-enhanced CT scan confirmed the collection, and a pigtail drain was inserted under ultrasound guidance, draining 250 ml of turbid fluid per day with high amylase levels. The patient was treated conservatively with octreotide and TPN, avoiding re-exploration. The drain output gradually decreased to 100 ml/day after two weeks and 50 ml/day after four weeks. After a total follow-up period of one and a half months, the drain output remained nil for three consecutive days, allowing for the removal of the pigtail drain, and the patient was discharged.

Mehdorn et al. (2022)<sup>8</sup> reported an incidence of 7.9% regarding postoperative pancreatic fistula in patients undergoing primary splenectomy. This is in concordance with our study where 10.34% of cases

experienced postoperative pancreatic fistula in distal ligation group.<sup>8</sup> Their study, however, included biochemical leak and postoperative pancreatic fistula. The incidence of postoperative pancreatic fistula only was 4.5%, which is like other literature.

Shen et al. (2020)<sup>15</sup> also reported a postoperative pancreatic fistula incidence of 4.2% with biochemical leak excluded. The incidence of biochemical leak alone was 6.6% in their study, making a total incidence of 10.8% out of 167 patients.<sup>14</sup>

In our study, POPF was observed only in the distal ligation group, with no cases reported in the proximal group. This is attributed to the increased manipulation at the splenic hilum in the distal group, which raises the likelihood of pancreatic tail injury and the development of POPF.

Regarding postoperative wound infection, there was a statistically significant difference between the two groups. The infection rate was 4.8% in the proximal group compared to 48.3% in the distal group ( $p=0.001$ ). This difference is primarily attributed to the longer operative times in the distal group and the occurrence of POPF cases in that group.

Cheng et al. (2017)<sup>16</sup> reported that the likelihood of surgical site infection increased with increasing time increments; for example, a 13%, 17%, and 37% increased likelihood for every 15 min, 30 min, and 60 min of surgery, respectively. On average, across various procedures, the mean operative time was approximately 30 min longer in patients with surgical site infections compared with those patients without. This supports the fact that longer operative time in the distal group was associated with increased risk of postoperative wound infection.<sup>15</sup>

Loos et al. (2018)<sup>17</sup> found that postoperative pancreatic fistula increased the risk of postoperative wound infection with statistically significant difference (30.0% vs 6.5%;  $P=.001$ ). This could suggest the increased incidence of postoperative wound infection in the distal group since both patients with postoperative pancreatic fistula in our study had distal ligation of the splenic artery and postoperative wound infection.<sup>16</sup>

A key finding was the significantly higher rate of postoperative wound infections in the distal ligation group, potentially linked to longer operative times. Literature supports a direct correlation between extended surgical duration and increased risk of surgical site infections. Additionally, pancreatic fistula has been associated with an increased likelihood of wound infections, which may explain the higher incidence in the distal group.<sup>15,16</sup>

Notably, there were no cases of portal vein thrombosis, a known complication of splenectomy, during the study period. Overall, our findings suggest that proximal splenic artery ligation may be



associated with shorter operative times and lower wound infection rates without compromising safety. Further prospective studies with larger sample sizes are needed to optimize the surgical approach and minimize postoperative complications.

## Conclusion

Our findings suggest that proximal splenic artery ligation is associated with shorter operative times and lower wound infection rates without increasing intraoperative or postoperative complications. While the risk of POPF was higher in the distal ligation group, further prospective studies with larger sample sizes are needed to refine surgical techniques and minimize postoperative morbidity.

## Limitations

The small sample size in both groups (29 patients in the distal group and 21 patients in the proximal group) limits the generalizability of our findings, highlighting the need for larger multicenter studies for validation. Additionally, the lack of similar studies for comparison further restricts the ability to contextualize our results.

## References

- Mazzola M, Crippa J, Bertoglio CL, Andreani S, Morini L, Sfondrini S, Ferrari G: Postoperative risk of pancreatic fistula after distal pancreatectomy with or without spleen preservation. *Tumori*. 2021; 107(2): 160-165.
- Abduljalil M, Saunders J, Doherty D, Dicks M, Maher C, et al: Evaluation of the risk factors for venous thromboembolism post splenectomy - A ten year retrospective cohort study in St James's hospital. *Ann Med Surg (Lond)*. 2021; 66: 102381.
- Camejo L, Nandeesha N, Phan K, Chharath K, Tran T, Ciesla D, et al: Infectious outcomes after splenectomy for trauma, splenectomy for disease and splenectomy with distal pancreatectomy. *Langenbecks Arch Surg*. 2022; 407(4): 1685-1691.
- Skandalakis L: Surgical anatomy and technique (5<sup>th</sup> ed.) *Springer*. 2021.
- Petrović F, Popovic M, Knezević Y, et al: Intraoperative and postoperative complications of splenectomy. *Acta Chir Jugosl*. 2002; 49(3): 81-84.
- Tahir F, Ahmed J, Malik F: Post-splenectomy sepsis: A review of the literature. *Cureus*. 2020; 12(2): e6898.
- Qu Y, Ren M, Li F, et al: Management of postoperative complications following splenectomy. *Int Surg*. 2013; 98(1): 55-60.
- Mehdorn F, Schwieters S, Mardin L, et al: Pancreatic fistula and biochemical leak after splenectomy: Incidence and risk factors. A retrospective single-center analysis. *Langenbecks Arch Surg*. 2022; 407(6): 2517-2525.
- Mazzola M, Crippa J, Bertoglio CL, Andreani S, Morini L, Sfondrini S, et al: Postoperative risk of pancreatic fistula after distal pancreatectomy with or without spleen preservation. *Tumori*. 2021; 107(2): 160-165.
- Khan MA, Kamran H, Ullah R, Zarin M: Laparoscopic splenectomy; single surgeon, single centre initial experience at tertiary level hospital in Peshawar. *J Ayub Med Coll Abbottabad*. 2021; 33(3): 488-491.
- Taner T, Nagorney DM, Tefferi A, Habermann TM, Harmsen WS, et al: Splenectomy for massive splenomegaly: Long-term results and risks for mortality. *Annals of Surgery*. 2013; 258(6): 1034-9.
- Ahmad I, Saleem S, Anjum S, Rehan AG. Splenectomy; postoperative splenectomy complications. *Professional Med J*. 2017; 24(9): 1322-1326.
- Bassi C, Marchegiani G, Dervenis C, Sarr M, Abu Hilal M, Adham M, Allen P, et al: International study group on pancreatic surgery (ISGPS) (2017) The 2016 update of the international Study Group (ISGPS) definition and grad-ing of postoperative pancreatic fistula: 11 years after. *Surgery*. 2017; 161: 584-591.
- Shen Y, Guo B, Wang L, et al: Significance of amylase monitoring in peritoneal drainage fluid after splenectomy: A clinical analysis of splenectomy in 167 patients with hepatolenticular degeneration. *The American SurgeonTM*. 2020; 86(4): 334-340.
- Cheng H, Chen BP, Soleas IM, et al: Prolonged operative duration increases risk of surgical site infections: A systematic review. *Surg Infect (Larchmt)*. 2017; 18(6): 722-735.
- Loos M, Strobel O, Legominski M, et al: Postoperative pancreatic fistula: Microbial growth determines outcome. *Surgery*. 2018; 164(6): 1185-1190.