Splenectomy for benign and malignant hematologic pathology: Modern morbidity, mortality, and long-term outcomes

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ABSTRACT

Background: The role of splenectomy to diagnose and treat hematologic disease continues to evolve. In this single-center retrospective review, we describe modern morbidity, mortality, and long-term outcomes associated with splenectomy for benign and malignant hematologic disorders.

Methods: We analyzed all nontrauma splenectomies performed for benign or malignant hematologic disorders from January 2009 to September 2018. Variables collected included demographics, preexisting comorbidities, laboratory results, intra- and postoperative features, and long-term follow-up. Outcomes of interest included postoperative complications, 30-day mortality, and overall mortality.

Results: We identified 161 patients who underwent splenectomy for hematologic disorders. Median age was 54 years (range 19–94), and 83 (52%) were female. Splenectomy was performed for 95 (59%) patients with benign hematologic disorders and for 66 (41%) with malignant conditions. Most splenectomies were laparoscopic (76%), followed by laparoscopic hand assisted (11%), open (8%), and laparoscopic converted to open (6%). Median follow-up was 761 days (interquartile range: 179–2025 days). Major complications occurred in 21 (13%) patients. Three (2%) patients died within 30 days; 16 (9%) died more than 30 days after operation, none from surgical complications, with median time to death of 438 days (interquartile range: 231–1497 days). Among malignant cases, only preoperative thrombocytopenia predicted death (odds ratio = 5.8, 95% confidence interval = 1.1–31.8, P = .04). For benign cases, increasing age was associated with inferior survival (odds ratio = 2.3, 95% confidence interval = 1.0–5.1, P = .05).

Conclusion: Splenectomy remains an important diagnostic and therapeutic option for patients with benign and malignant hematologic disorders and can be performed with a low complication rate. Despite considerable burden of comorbid disease in these patients, early postoperative mortality was uncommon.

BACKGROUND

Splenectomy has been an essential diagnostic and therapeutic option in the management of benign and malignant hematologic disorders. Indications for splenectomy have evolved owing to improvements in noninvasive diagnostic testing, availability of medical therapies, and advances in surgical techniques including laparoscopy [1–3]. Physician and patient perceptions of perioperative and long-term risks associated with splenectomy may dissuade them from pursuing surgical intervention, especially with the increase in number of medical therapies. This has created the perception of splenectomy as a third-line option and could lead to delays in surgical therapy which may impact patient outcomes [4].

The burden of pathology associated with the underlying hematologic disease, potential adverse effects of medical therapy, and patients' goals of care mandate a thorough understanding of the risks and benefits of splenectomy in an increasingly complex treatment landscape [5–7]. Yet, the morbidity and mortality rates of splenectomy remain incompletely characterized. To inform this decision making, we describe the modern morbidity, mortality, and long-term outcomes associated with splenectomy for benign and malignant hematologic conditions.

METHODS

We performed a retrospective analysis of splenectomies performed for benign or malignant hematologic disorders at our institution from January 1, 2009, to September 15, 2018. All patients undergoing splenectomy with concomitant diagnoses of benign or malignant

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Table 1

Demographic, intraoperative, and postoperative variables for patients undergoing splenectomy for benign and malignant hematologic malignancy (2009–2018)

	All cases	Benign (n = 95)	Malignant (n = 66)	P value
Demographic variables				
Male sex (%)	78 (48)	35 (37)	43 (64)	P < .0001
Age, median (range), y	54 (19–94)	45 (19–94)	62 (21–83)	P < .0001
Race, no. (%)				
White	99 (61)	51 (54)	48 (73)	P = .01
Hispanic	28 (17)	23 (24)	5 (8)	
Asian	18 (11)	8 (8)	10 (15)	
Other	11 (7)	8 (8)	3 (5)	
Black	3 (2)	3 (3)	0 (0)	
Native Hawaiian	1 (1)	1 (1)	0 (0)	
American Indian	1 (1)	1 (1)	0 (0)	
Benign, no. (%)	95 (59)			
Autoimmune hemolytic anemia		19 (12)		
Beta thalassemia		1 (1)		
Evans syndrome		4 (2)		
Hereditary spherocytosis		10 (6)		
Idiopathic thrombocytopenic purpura		60 (37)		
Thrombotic thrombocytopenic purpura		1 (1)		
Malignant, no. (%)	66 (41)			
Angioimmunoblastic T-cell lymphoma			1 (1)	
B-cell lymphoma			5 (3)	
Chronic lymphoblastic leukemia			5 (3)	
Diffuse large B-cell lymphoma			9 (6)	
Chronic myelomonocytic leukemia			1 (1)	
Epstein-Barr virus–related T-cell lymphoproliferative syndrome			1 (1)	
Follicular lymphoma			4 (2)	
Hodgkin lymphoma			5 (3)	
Large B-cell lymphoma			3 (2)	
Low-grade B-cell lymphoma			4 (2)	
Mantle cell lymphoma			6 (4)	
Marginal zone lymphoma			13 (8)	
Myelodysplastic syndrome			1 (1)	
Natural killer cell low-grade lymphoma			1 (1)	
T-cell large granular lymphocytic leukemia			2 (1)	
T-cell lymphoma			5 (3)	
Comorbidities, no. (%)				
Hypertension	62 (39)	35 (37)	27 (41)	P = .6
Hyperlipidemia	41 (25)	19 (20)	22 (33)	P = .07
Diabetes	26 (16)	15 (16)	11 (16)	P = 1.0
Chronic obstructive pulmonary disease	6 (4)	5 (5)	1 (1)	P = .4
Asthma	8 (5)	5 (5)	3 (4)	P = 1.0
Renal disease	12 (7)	8 (8)	4 (6)	P = .8
Cardiac disease	22 (14)	10 (11)	12 (18)	P = .2
Chronic steroid use	61 (38)	55 (58)	6 (9)	P < .0001
Current or former smoker	56 (35)	28 (29)	28 (42)	P = .1
Partially or completely dependent	5 (3)	0 (0)	5 (7)	P = .01
Leukopenia	29 (19)	8 (9)	21 (32)	P = .001
Anemia	93 (61)	50 (56)	43 (67)	P = .2
Thrombocytopenia	46 (30)	31 (35)	15 (23)	P = .1
Hypoalbuminemia	55 (49)	30 (50)	25 (48)	P = .9
Coagulopathy	22 (24)	9 (18)	13 (32)	P = .1
Hyperbilirubinemia	29 (26)	17 (29)	12 (23)	P = .5
Treatment and outcome variables				
Splenectomy approach, no. (%)				
Open	12 (8)	5 (5)	7 (11)	P < .0001
Laparoscopic	122 (76)	83 (88)	39 (59)	
Laparoscopic hand assisted	18 (11)	5 (5)	13 (20)	
Laparoscopic converted to open	9 (6)	2 (2)	7 (11)	
Intraoperative transfusion required, no. (%)	33 (20)	17 (18)	16 (24)	P = .3
Weight of spleen, median (range), g	306.5 (49–5650)	182.5 (49–1900)	742 (82–5650)	P < .0001
Accessory spleen present, no. (%)	13 (8)	9 (9)	4 (6)	P = 1.0
Hospital length of stay, median (range), d	2 (1–41)	2 (1–27)	3 (1–41)	P = .01
Required intensive care unit admission, no. (%)	9 (6)	5 (5)	4 (6)	P = 1.0
Patients with complications, no. (%)	21 (13)	14 (15)	7 (11)	P = .5
Portal, mesenteric, or splenic vein thrombosis	9 (6)	7 (7)	2 (3)	P = .3
Postoperative bleed requiring transfusion	5 (3)	2 (2)	3 (4)	P = .4
DVT or pulmonary embolism	5 (3)	4 (4)	1 (2)	P = .6
Surgical site infection	5 (3)	3 (3)	2 (3)	P = 1.0
Sepsis	4 (2)	3 (3)	1 (1)	P = .6
Pneumonia	3 (2)	2 (2)	1 (1)	P = 1.0
Pancreatic leak	2 (1)	1 (1)	1 (1)	P = 1.0
Renal failure	1 (1)	1 (1)	0 (0)	P = 1.0
Overwhelming postsplenectomy sepsis	1 (1)	1 (1)	0 (0)	P = 1.0
Reoperation required	1 (1)	1 (1)	0 (0)	P = 1.0
Postoperative DVT chemoprophylaxis used	81 (50)	41 (43)	40 (61)	P = .04

Table I (continued)

	All cases	Benign (n = 95)	Malignant (n = 66)	P value
Postdischarge DVT chemoprophylaxis prescribed	20 (12)	18 (19)	2 (3)	P = .003
Total deaths, no. (%)	19 (12)	5 (5)	14 (21)	P = .005
Death within 30 d, no. (%)	3 (2)	2 (2)	1 (1)	P = 1.0
Death after 30 d, no. (%)	16 (9)	3 (3)	13 (19)	P = .001
Time to death if more than 30 d after surgery, median (range), d	447 (44–2477)	378 (250–2477)	447 (44–2052)	P = .6
Follow-up, median (range), d	761 (2–3560)	643 (2–3323)	917 (6–3560)	P = .1

DVT, deep vein thrombosis.

hematologic pathology were included. Splenectomies performed for trauma or for other nonhematologic malignancies and splenectomies performed on persons <18 years of age were excluded. Variables assessed included demographics, preexisting comorbidities and laboratory results, intra- and postoperative features, and long-term follow-up variables. *Leukopenia* was defined as a white blood cell count <4.0 × 10^9/L. *Anemia* was defined as a hemoglobin <12 g/dL for females and <13 g/dL for males. *Thrombocytopenia* was defined as <50,000 platelets/μL. *Hypoalbuminemia* was defined as <3.5 g/dL. An *elevated total bilirubin* was defined as >1.2 mg/dL. *Coagulopathy* was defined as an international normalized ratio > 1.3. Patient records were evaluated until death or last documented follow-up within our health care system. Outcomes of interest included postoperative complications, 30-day mortality, and overall mortality. Complications were evaluated as end points independent of death.

Fisher exact and Mann-Whitney *U* tests were used for univariate analysis where appropriate. An a priori *P* value considered significant on univariate analysis for inclusion into multivariate models was *P* < .1; a *P* < .05 was considered significant on multivariate analysis. Multivariate logistic regression was used to assess predictors of postoperative complication and mortality. Stata 12.0 (StataCorp, College Station, TX) was used for statistical analyses. This study received institutional review board approval.

RESULTS

There were 161 patients who had a splenectomy over the 10-year time period (Table I). Ninety-five (59%) patients had a splenectomy performed for benign conditions, with immune thrombocytopenia being the most common indication (*n* = 60, 63% of benign indications). Sixty-six (41%) patients had a splenectomy performed for malignant conditions; the most frequent diagnosis was marginal zone lymphoma (*n* = 13, 20% of malignant indications). Median patient age was 54 years (range: 19–94), and 83 (52%) were female. Patients diagnosed with malignant disease were significantly older (62 vs 45 years, *P* < .0001). Common comorbidities among patients included anemia (*n* = 93/152, 61%), hypoalbuminemia (*n* = 55/112, 49%), hypertension (*n* = 62/159, 39%), chronic steroid use (*n* = 61/161, 38%), and a history of smoking (*n* = 66/161, 41%). Chronic steroid use was more common among patients with benign pathology (58% vs 9%, *P* < .0001). The only patients who were partially or completely dependent on others with respect to activities of daily living were patients with hematologic malignancies (*n* = 5, 7%). Leukopenia was more common among patients with hematologic malignancies compared to benign pathology (32% vs 9%, *P* = .001).

There were 122 (76%) laparoscopic splenectomies, 18 (11%) laparoscopic hand-assisted splenectomies, 12 (8%) open splenectomies, and 9 (6%) laparoscopic converted to open splenectomies. Average spleen weight in our cohort was 306.5 g (range: 49.0–5650.0 g), and spleen weight was significantly higher in the malignant group (742.0 vs 182.5 g, *P* < .0001). Open, laparoscopic hand-assisted, and laparoscopic cases converted to open were more common among patients with hematologic malignancies when compared to benign pathology (11% vs 5%, 20% vs 5%, and 11% vs 2%, respectively; *P* < .0001). Thirty-three (20%) splenectomies required intraoperative transfusion with packed red blood cells, fresh-frozen plasma, or platelets because of preoperative

anemia or thrombocytopenia and intraoperative blood loss. Median hospital length of stay was 2 (range: 1–41) days, and 9 (6%) patients required intensive care unit admission postoperatively. The median hospital length of stay was longer for patients with hematologic malignancies versus those with benign disorders (2 vs 3 days, *P* = .01). The most common complication after surgery was portal, mesenteric, or splenic vein thrombosis (*n* = 9, 6%). Other postoperative complications included postoperative bleeding requiring transfusion (*n* = 5, 3%), peripheral deep vein thrombosis or pulmonary embolism (*n* = 5, 3%), surgical site infection (*n* = 5, 3%), sepsis (*n* = 4, 2%), pneumonia (*n* = 3, 2%), pancreatic leak (*n* = 2, 1%), renal failure (*n* = 1, 1%), and overwhelming postsplenectomy sepsis (*n* = 1, 1%). Complication rates were not significantly different between patients with benign and malignant pathology. Reoperation for bleeding was required for 1 (1%) patient.

Nineteen (12%) patients died during follow-up, 3 (2%) of whom died within 30 days. Of the 3 patients who died within 30 days of surgery, 1 was a patient with T-cell lymphoma who died after suffering a cerebrovascular accident and decompensated heart failure on postoperative day (POD)6. The second patient with a diagnosis of immune thrombocytopenic purpura (ITP) died after developing diffuse alveolar hemorrhage and respiratory failure on POD13. The third patient with a diagnosis of Evans syndrome died on POD15 after developing a pulmonary embolus and cardiac arrest. Among the 16 (9%) of patients who died after 30 days, median time to death was 438 (interquartile range [IQR]: 231–1497) days. Death after 30 days was more common among patients with hematologic malignancy (*n* = 13, 19%) compared to patients with benign pathology (*n* = 3, 3%, *P* = .001) (Fig). Median follow-up among all patients, both those who survived and those who died, was 761 (IQR: 179–2025) days.

Eighty-one (50%) patients were started postoperatively on venous thromboembolic (VTE) chemoprophylaxis, more commonly among patients with malignant than benign disorders (61% vs 43%, *P* = .04). Receipt of VTE prophylaxis was not associated with a reduction in VTE incidence or an increase in bleeding rates compared to patients who did not receive VTE prophylaxis, although event rates were low.
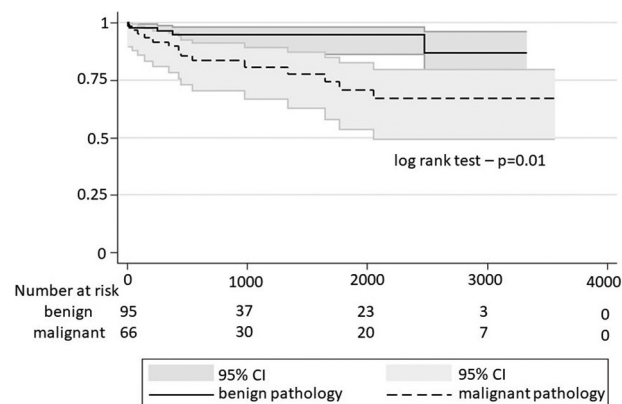

Fig. Kaplan-Meier survival curve estimates for patients after splenectomy for benign and malignant hematologic pathology.

Table II
Predictors of complications and death after splenectomy for benign conditions

	All patients (n = 95)	Complications (n = 14)	P value	Death (n = 5)	P value
Demographic variables					
Male sex, no. (%)	35 (37)	2 (15)	P = .1	1 (20)	P = .6
Age, median (range), y	44 (19–94)	48 (22–94)	P = .7	65 (50–94)	P = .006
Race, no. (%)					
White	51 (54)	8 (57)	P = .8	3 (60)	P = .9
Hispanic	23 (24)	5 (36)		2 (40)	
Asian	8 (8)	1 (7)		–	
Other	8 (8)	–		–	
Black	3 (3)	–		–	
Native Hawaiian	1 (1)	–		–	
American Indian	1 (1)	–		–	
Hypertension, no. (%)	35 (37)	6 (43)	P = 1.0	4 (80)	P = .06
Hyperlipidemia, no. (%)	19 (20)	3 (23)	P = .7	2 (40)	P = .3
Diabetes, no. (%)	15 (16)	1 (8)	P = .5	0 (0)	P = 1.0
Chronic obstructive pulmonary disease, no. (%)	5 (5)	2 (15)	P = .2	1 (20)	P = .2
Asthma, no. (%)	5 (5)	0 (0)	P = 1.0	0 (0)	P = 1.0
Renal disease, no. (%)	8 (8)	1 (8)	P = 1.0	0 (0)	P = 1.0
Cardiac disease, no. (%)	10 (11)	1 (8)	P = 1.0	1 (20)	P = .44
Chronic steroid use, no. (%)	55 (58)	9 (64)	P = .8	4 (80)	P = .4
Current or former smoker, no. (%)	28 (30)	4 (31)	P = 1.0	2 (40)	P = .6
Partially or completely dependent, no. (%)	0 (0)	–	–	–	–
Leukopenia, no. (%)	8 (9)	2 (15)	P = .3	1 (20)	P = .4
Anemia, no. (%)	50 (56)	10 (77)	P = .1	5 (100)	P = .07
Thrombocytopenia, no. (%)	31 (35)	4 (31)	P = 1.0	3 (60)	P = .3
Hypoalbuminemia, no. (%)	30 (50)	3 (50)	P = 1.0	4 (100)	P = .05
Coagulopathy, no. (%)	9 (18)	3 (43)	P = .06	1 (33)	P = .4
Hyperbilirubinemia, no. (%)	17 (29)	5 (83)	P = .006	1 (25)	P = 1.0
Treatment and outcome variables					
Splenectomy approach, no. (%)					
Open	5 (5)	0 (0)	P = .1	1 (20)	P = .1
Laparoscopic	83 (88)	11 (85)		3 (60)	
Laparoscopic hand assisted	5 (5)	2 (17)		1 (20)	
Laparoscopic converted to open	2 (2)	1 (7)		0 (0)	
Intraoperative transfusion required, no. (%)	17 (18)	4 (29)	P = .3	3 (60)	P = .04
Weight of spleen, median (range), g	182.5 (49–1900)	260 (88–870)	P = .3	181 (71–360)	P = .5
Accessory spleen present, no. (%)	9 (9)	2 (14)	P = .6	1 (20)	P = .4
Hospital length of stay, median (range), d	2 (1–27)	3 (1–27)	P = .05	6 (1–14)	P = .05
Required intensive care unit admission, no. (%)	5 (5)	4 (31)	P = .001	2 (40)	P = .02
Duration intensive care unit admission, median (range), d	<1 (<1–12)	<1 (<1–12)	P < .0001	<1 (<1–12)	P < .0001
Postoperative DVT chemoprophylaxis used	41 (43)	8 (57)	P = .4	2 (40)	P = 1.0
Postdischarge DVT chemoprophylaxis prescribed	18 (19)	2 (11)	P = 1.0	0 (0)	P = .6

In univariate analysis of patients with benign hematologic disorders, demographic variables associated with complications included male sex (n = 2/13, 15%, P = .1), anemia (n = 10/13, 77%, P = .1), coagulopathy (n = 3/7, 43%, P = .06), and hyperbilirubinemia (5/6, 83%, P = .006) (Table II). Variables associated with mortality on univariate analysis among the same benign hematologic pathology subgroup included increased age (P = .006), hypertension (n = 4/5, 80%, P = .06), anemia (n = 5/5, 100%, P = .07), and hypoalbuminemia (n = 4/4, 100%, P = .05). On multivariate analysis, no patient demographic factors were associated with development of complications. Even after excluding patients with ITP, no demographic variable was associated with development of complications. Only increased age was associated with death after splenectomy for benign hematologic conditions (odds ratio [OR] = 2.26, 95% confidence interval [CI] 1.00–5.11) on multivariate analysis.

Among patients who underwent splenectomy for malignant hematologic indications, chronic steroid use (n = 2/7, 29%, P = .1), thrombocytopenia (n = 5/8, 63%, P = .006), hypoalbuminemia (n = 6/7, 86%, P = .04), and coagulopathy (n = 4/6, 67%, P = .03) were associated with complications on univariate analysis (Table III). Hypertension (n = 3/14, 21%, P = .1), thrombocytopenia (n = 7/14, 50%, P = .01), hypoalbuminemia (n = 9/12, 75%, P = .05), and hyperbilirubinemia (n = 5/12, 42%, P = .1) were associated with death on univariate analysis. Similar to patients with benign disorders, on multivariate analysis, there were no demographic variables that remained associated with the composite complication variable among patients with malignant conditions; only

thrombocytopenia was associated with death (OR = 5.76, 95% CI 1.05–31.77, P = .04).

DISCUSSION

New treatment options have emerged for the management of benign and malignant hematologic disorders including the use of monoclonal antibodies, immune-modulating therapies, and synthetic thrombopoietin receptor agonists [8,9]. As a result, indications for splenectomy in the management of these diseases have undergone considerable evolution over the last decade [10,11]. Despite these new treatment options, surgical intervention with splenectomy has remained an important diagnostic and therapeutic option for patients with recalcitrant disease and complications from splenomegaly.

In this single-center retrospective analysis, we describe 161 patients who underwent splenectomy for a variety of benign and malignant hematologic disorders. We demonstrate that the majority of patients in this cohort underwent successful splenectomy with a relatively low rate of postoperative complications. Both short- and long-term postoperative mortality rates were low in our cohort. Most (76%) patients are able to undergo laparoscopic surgery, irrespective of spleen size. This is consistent with recent findings that laparoscopic splenectomy has replaced open splenectomy as the criterion standard surgical intervention even in patients with massive splenomegaly [12].

Both laparoscopic splenectomy and open splenectomy were performed with very low rates of complications. The most common

Table III
Predictors of complications and death after splenectomy for malignant conditions

	All patients (n = 66)	Complications (n = 7)	P value	Death (n = 14)	P value
Demographic variables					
Male sex, no. (%)	43 (64)	5 (63)	P = 1.0	8 (57)	P = .5
Age, median (range), y	62 (21–83)	68 (45–74)	P = .2	59 (34–83)	P = .6
Race, no. (%)					
White	48 (73)	5 (71)	P = .8	10 (71)	P = .3
Hispanic	5 (8)	1 (14)		–	
Asian	10 (15)	1 (14)		4 (29)	
Other	3 (5)	–		–	
Black	0 (0)	–		–	
Native Hawaiian	0 (0)	–		–	
American Indian	0 (0)	–		–	
Hypertension, no. (%)	27 (41)	3 (43)	P = 1.0	3 (21)	P = .1
Hyperlipidemia, no. (%)	22 (33)	2 (25)	P = 1.0	5 (36)	P = 1.0
Diabetes, no. (%)	11 (16)	0 (0)	P = .3	2 (14)	P = 1.0
Chronic obstructive pulmonary disease, no. (%)	1 (1)	0 (0)	P = 1.0	0 (0)	P = 1.0
Asthma, no. (%)	3 (4)	1 (14)	P = .3	2 (14)	P = .1
Renal disease, no. (%)	4 (6)	0 (0)	P = 1.0	0 (0)	P = 1.0
Cardiac disease, no. (%)	12 (18)	1 (14)	P = 1.0	1 (7)	P = .44
Chronic steroid use, no. (%)	6 (9)	2 (29)	P = .1	1 (7)	P = 1.0
Current or former smoker, no. (%)	28 (42)	2 (25)	P = .7	6 (43)	P = 1.0
Partially or completely dependent, no. (%)	5 (7)	1 (13)	P = .4	2 (14)	P = .3
Leukopenia, no. (%)	21 (32)	3 (43)	P = .7	6 (43)	P = .4
Anemia, no. (%)	43 (67)	6 (86)	P = .4	11 (79)	P = .4
Thrombocytopenia, no. (%)	15 (23)	5 (63)	P = .006	7 (50)	P = .01
Hypoalbuminemia, no. (%)	25 (48)	6 (86)	P = .04	9 (75)	P = .05
Coagulopathy, no. (%)	13 (32)	4 (67)	P = .03	4 (40)	P = .7
Hyperbilirubinemia, no. (%)	12 (23)	3 (43)	P = .3	5 (42)	P = .1
Treatment and outcome variables					
Splenectomy approach, no. (%)					
Open	7 (11)	1 (14)	P = .3	0 (0)	P = .08
Laparoscopic	39 (59)	3 (43)		8 (57)	
Laparoscopic hand assisted	13 (20)	1 (14)		2 (14)	
Laparoscopic converted to open	7 (11)	2 (29)		4 (29)	
Intraoperative transfusion required, no. (%)	16 (24)	5 (71)	P = .007	7 (50)	P = .03
Weight of spleen, median (range), g	742 (82–5650)	800 (265–5650)	P = .8	762 (190–2850)	P = .4
Accessory spleen present, no. (%)	4 (6)	0 (0)	P = 1.0	0 (0)	P = .6
Hospital length of stay, median (range), d	3 (1–41)	6 (1–18)	P = .08	4 (1–26)	P = .09
Required intensive care unit admission, no. (%)	4 (6)	1 (13)	P = .4	0 (0)	P = .6
Duration intensive care unit admission, median (range), d	<1 (<1–12)	N/A	N/A	N/A	N/A
Postoperative DVT chemoprophylaxis used	40 (61)	2 (29)	P = .1	6 (15)	P = .1
Postdischarge DVT chemoprophylaxis prescribed	2 (3)	0 (0)	P = 1.0	0 (0)	P = 1.0

N/A, not applicable. Only 1 patient.

complication was portal, mesenteric, and splenic vein thrombosis (cumulative 6%). After identification of thrombosis, these patients were treated successfully with systemic anticoagulation and did not require further operative intervention. This is consistent with practice recommendations from a meta-analysis which showed 67% complete resolution of symptomatic splenic vein thrombosis after splenectomy with therapeutic anticoagulation [13]. The increased risk of portal vein thrombosis in patients undergoing splenectomy is thought to be secondary to the acute increase in platelet count and reduction in portal blood flow after removal of the spleen [14]. Interestingly, the use of postoperative VTE chemoprophylaxis was associated with neither VTE incidence nor bleeding rate. It is important to note that our study was retrospective and not adequately powered to evaluate or quantify the impact of VTE prophylaxis on thrombosis or bleeding risk. A recent meta-analysis by Qi et al showed that prophylactic anticoagulation led to a decrease in portal venous system thrombosis with no increased risk of bleeding in patients with portal hypertension and hypersplenism. However, the effect in patients with hematological disorders remained inconclusive because of limited evidence [15]. Given the variability in VTE chemoprophylaxis prescribing patterns [16], a prospective randomized study evaluating chemical prophylaxis in patients with hematologic disorders undergoing splenectomy seems warranted.

The overall long-term survival in our patient population was favorable. Throughout the 30-day follow-up period, mortality rate was low, and none of the deaths was directly related to surgical intervention but rather due to complications from progressive hematologic disease. Compared to 2 previous studies, we observed significantly lower rates of postoperative complications and mortality [17,18]. Although this could be explained by the relatively shorter duration of follow-up in our study (10 vs 27 years), we believe that this reduction in postoperative complications and mortality is likely due to improved understanding of the underlying disease processes, better critical care, and more effective perioperative management [19]. The low perioperative mortality, despite the slightly shorter follow-up period in our study, supports our conclusion that splenectomy is safe and can be used as a low-risk diagnostic and therapeutic option when appropriately used.

Independent predictors of mortality in our patient population were increased age (among patients with benign disease) and thrombocytopenia (among patients with malignant disease). Bagrodia et al in their analysis of the morbidity and mortality after elective splenectomy using the National Surgical Quality Improvement Program database also found increased age and preoperative albumin level to be independent predictors of mortality [17]. When discussing potential outcomes, older patients should be warned that they may be at higher risk of adverse events. Frail older adults may be at particularly high risk. Although we were not able to capture frailty in our retrospective patient cohort, frailty is increasingly shown to be a more specific predictor of postoperative morbidity than age [20]. The impact of frailty may be particularly pronounced among patients who are immunosuppressed as a result of their underlying pathology or treatment.

Thrombocytopenia is commonly observed among patients with hematologic malignancy and can be seen in 5%–30% of patients depending on the underlying pathology. In our cohort, thrombocytopenia was an independent predictor of mortality among patients with malignant hematologic disorders. Recent data among critically ill patients with hematologic malignancy indicate inferior outcomes among patients with thrombocytopenia and organ failure compared to those without [19]. It is possible that preexisting thrombocytopenia is reflective of more advanced disease preoperatively, resulting from chemotherapy, disseminated intravascular coagulation, bone marrow failure, or a combination thereof [19].

At our institution, patients undergoing elective splenectomy for benign/malignant diseases typically receive vaccination against encapsulated organisms (*Streptococcus pneumoniae, Haemophilus influenzae* type B, *Neisseria meningitidis*) 2 weeks or more prior to their operation. In cases where an emergent operation is performed, the prophylactic vaccines are administered in the postoperative period prior to discharge. All patients are educated regarding the risks of asplenia, immunosuppression, and overwhelming postsplenectomy sepsis. Barring any postoperative complications, patients are seen in scheduled follow-up 2 weeks postdischarge.

There are several limitations to this study. Firstly, this was a retrospective, single-institution study, and as such, our results may not be generalizable to other patient populations or institutions. Secondly, because we did not do a subgroup analysis of the various benign and malignant hematologic conditions, it is possible that important predictors of both morbidity and mortality in these patients could be obscured or missed for specific disease entities. Given the low group numbers of some of the conditions, we elected to not do specific subgroup analyses beyond malignant or benign categories. Finally, our study only included patients with hematologic diseases who underwent splenectomy. We did not include patients who were never referred to a surgeon or who were not taken for splenectomy after evaluation by a surgeon. We are unable to compare survival rates after surgery to a control group of patients with hematologic disorders not undergoing splenectomy. Selection bias may be present among patients undergoing surgery, as patients too frail to undergo surgery were selected out.

In conclusion, splenectomy remains an important adjunct for the management of patients with both benign and malignant hematologic disorders and can be performed with a low rate of complications using minimally invasive strategies. Despite a considerable burden of comorbid disease in this patient population, early postoperative mortality is uncommon, and the overall long-term survival after splenectomy is measured in years. Surgical intervention should be considered a tool that can be used selectively to improve outcomes in patients with hematologic disorders.

Author Contribution

Wilson M Alobuia: Conceptualization, Data curation, Formal analysis, Writing – original draft; **Kenneth Perrone**: Conceptualization, Data curation, Formal analysis, Writing – original draft; **David J. Iberri**: Resources, Writing – review & editing; **Rondeep S. Brar**: Resources, Writing – review & editing; **David A. Spain**: Conceptualization, Supervision, Writing – review & editing; **Joseph D Forrester**: Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing.

Conflict of Interest

The authors have no conflicts of interest to report.

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