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Efficacy and Safety of Trans-Arterial Splenic Embolization

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Abstract

Introduction: As experience with the long-term complications of the asplenic state has accumulated, greater interest and effort has focused on splenic preservation techniques. Trans-arterial splenic embolization has emerged as a relatively safe and efficacious procedure in dealing with traumatic splenic injuries. The outcomes following this procedure, in terms of efficacy, complications, and long-term splenic function, have yet to be clearly defined. The purpose of this study was to document these outcomes in patients undergoing trans-arterial splenic embolization at a single tertiary care center.

Methods: A retrospective chart review of all patients that underwent trans-arterial splenic embolization at the University of Alberta Hospital was undertaken. Various patient characteristics and procedure details were recorded. Patient outcomes, in terms of infections, procedural failures, and peripheral blood smear results, were also recorded. Univariate analysis was done to determine the correlation of various patient and procedure variables with failure, infection, splenic infarction, and peripheral blood smear (PBS) results.

Results: A total of 19 patients underwent trans-arterial splenic embolization at the University of Alberta Hospital from January 2005 to January 2009. No variables correlated in a statistically significant manner to hemorrhage, infection, repeat embolization, splenic infarction, or abnormal PBS. Our results revealed that trans-arterial splenic embolization does not lead to long-term loss of splenic function.

Conclusions: Trans-arterial splenic embolization is a safe and effective procedure that does not lead to long-term compromise of splenic function. Complications and failures of this procedure, however, cannot be predicted based on either patient or procedure characteristics examined in this study.

Key words: *Splenic Preservation, Splenic Injury, Splenic Embolization*

Introduction

Traditionally, surgeons have viewed the spleen as an organ that can be removed without consequence in the context of trauma or adjacent disease. As the understanding of the consequences of asplenism became apparent, particularly in children [1,2], the importance of splenic function began to garner greater appreciation. This has spurred signifi-

cant interest over the last two decades in splenic preservation, especially in the pediatric population. In blunt splenic trauma with hemodynamically stable patients, non-operative management, where possible, has become the standard practice [3]. The success rates of non-operative management in such situations have been observed to vary from 80 to 98% [4-7]. One of the tools that has enabled increased success with, and reliance on, non-operative management is visceral angiography and trans-arterial embolization (TAE). This procedure, when used in conjunction with hemodynamic resuscitation and close observation, has been found to significantly reduce the need for surgery in such patients [8-11]. The safety and efficacy of this procedure is not entirely known, as variable results have been reported by a number of studies [12,13].

Beyond the immediate efficacy and safety profile, the other unknown with splenic embolization is long-term splenic function following the procedure. The predominant rationale for this procedure is to avoid laparotomy and splenectomy; this is partly to preserve long-term splenic function. The procedure involves disrupting the spleen's blood supply and has been reported to result in splenic infarction and necrosis. Preservation of long-term splenic function is therefore not as obvious as it may initially seem, and several studies have in fact demonstrated long-term impairment of splenic function. Studies preformed to date, however, have generally suggested that the majority of patients retain splenic function following embolization; however, conclusive evidence for the preservation of splenic function following embolization has not been presented. The efficacy and long-term effects, including long-term splenic function, of the technical options in TAE (proximal versus distal TAE), as well as the choice of embolic material used, such as Gelfoam, polyvinyl alcohol (PVA), liquid embolics, coils and occlusion devices, remain unknown.

The purpose of this study was to review the experience with splenic embolization at a single tertiary care center. We specifically aimed to determine the efficacy, safety, and effects on long-term splenic function of this procedure.

Methods

A retrospective chart and procedural record review of all patients who underwent trans-arterial splenic angioembolization at the University of Alberta Hospital from January 2005 to January 2009. Ethics approval from the Health Ethics Research Board at the University of Alberta was obtained for the study. The University of Alberta Hospital is a tertiary care trauma center in the city of Edmonton with a catchment population approaching 3 million and serving a large geographic area of western Canada. Variables recorded included: reason for embolization, grade of splenic injury, associated injuries, presence of extravasation (blush) on CT, comorbid medical conditions, platelet and white blood cell counts before and after embolization, post-procedure complications (ex: infections and bleeding), repeat embolization, salvage splenectomy, extent of embolization (proximal vs. distal), peripheral blood smear (PBS) results, and results of follow-up imaging. Comorbid medical conditions for the purpose of this study were defined as one of: chronic obstructive pulmonary disease (COPD), ischemic heart disease, cardiac arrhythmias, cardiac valvular disease, diabetes mellitus, chronic renal failure, and/or cerebral vascular disease. All patients were followed with a CT scan with a mean follow-up time of 6.6 months from the time of embolization.

Statistical Methods

Descriptive statistics were generated for the collected variables. Frequency and proportions were reported for the categorical variable. Mean and standard deviations were reported for continuous variables, and medians and ranges were reported for non-normal data. Univariate analysis was used to determine which factors correlated with rates of infection, embolization failure (as defined by repeat embolization and/or salvage splenectomy), splenic infarction, and PBS results indicative of loss of splenic function. The univariate analysis between two continuous variables was tested using Independent student's t-tests, while chi-square tests were used to study the correlation between two categorical variables. All statistical analysis was conducted using SAS (SAS Institute Inc., Cary, NC) version 9.2 software, and a p- value less than 0.05 was considered for all statistical significance.

Results

A total of 19 patients were identified as having undergone splenic embolization at the University of Alberta Hospital for the 4-year study period. Table 1 summarizes the study outcomes according to the characteristics of the overall patient sample. The median age for our cohort was 53 years (range of 13-78 years). The mean follow-up period for our cohort was 5.2 months. The majority of the overall cohort were male (73.7%) and the entire trauma patient cohort were male. Of the 19 patients included in our study, 11 (57.9%) had undergone splenic embolization for trauma, 5 (26.3%) for pseu-

Table 1. Outcomes according to overall patient sample

Variable	All Patients		p-value
	Female (%)	**Male (%)**	
Plt Increase=1	3 (60)	8 (62)	0.99
Plt Increase=2	2 (40)	5 (39)	
WBC Increase=1	1 (20)	2 (15)	0.99
WBC Increase=2	4 (80)	11 (85)	
Infection=1	1 (20)	1 (7)	0.47
Infection=2	4 (80)	13 (93)	
Salvage Spleen=1	1 (20)	2 (17)	0.99
Salvage Spleen=2	4 (80)	10 (83)	
	Reason=1	**Reason=2**	
Plt Increase=1	6 (60)	5 (63)	0.99
Plt Increase=2	4 (40)	3 (38)	
WBC Increase=1	1 (10)	2 (25)	0.56
WBC Increase=2	9 (90)	6 (75)	
Infection=1	0 (0)	2 (25)	0.16
Infection=2	11 (100)	6 (75)	
Salvage Spleen=1	1 (11)	2 (25)	0.58
Salvage Spleen=2	8 (89)	6 (75)	
	Comorbidity=1	**Comorbidity=2**	
Plt Increase=1	5 (71)	6 (55)	0.64
Plt Increase=2	2 (29)	5 (46)	
WBC Increase=1	2 (29)	1 (9)	0.53
WBC Increase=2	5 (71)	10 (91)	
Infection=1	1 (14)	1 (8)	0.99
Infection=2	6 (86)	11(92)	
Salvage Spleen=1	0 (0)	3 (27)	0.51
Salvage Spleen=2	6 (100)	8 (73)	
	Material=1	**Material=2**	
Plt Increase=1	5 (71)	4 (50)	0.61
Plt Increase=2	2 (29)	4 (50)	
WBC Increase=1	2 (29)	1 (12)	0.57
WBC Increase=2	5 (71)	7 (88)	
Infection=1	1 (13)	1 (13)	0.99
Infection=2	7 (88)	7 (88)	
Salvage Spleen=1	0 (0)	3 (38)	0.20
Salvage Spleen=2	8 (100)	5 (62)	
	Extent=1	**Extent=2**	
Plt Increase=1	5 (56)	4 (67)	0.99
Plt Increase=2	4 (44)	2 (33)	
WBC Increase=1	1 (11)	2 (33)	0.52
WBC Increase=2	8 (89)	4 (67)	
Infection=1	1 (11)	1 (14)	0.99
Infection=2	8 (89)	6 (86)	
Salvage Spleen=1	3 (33)	0 (100)	0.21
Salvage Spleen=2	6 (67)	7 (100)	

** Statistics cannot be computed*

doaneurysms, 2 (10.5%) as a preoperative measure prior to splenectomy, and 1 (5.3%) for left-sided portal hypertension. Table 2 summarizes the differences between the overall and trauma cohorts, with regard to the study outcomes. Of the 11 trauma patients, 6 had evidence of a vascular blush on CT, indicating active extravasation of blood. Table 3 summarizes the outcomes of the trauma subgroup in our cohort; 6 out of the 19 patients showed thrombocytosis after embolization with a median follow-up period of 4.5 months. On the other hand, only 2 patients showed an elevated WBC after embolization. Of the 19 patients, five had a hemorrhage after embolization; one of these patients underwent repeat angioembolization, whereas three were treated with transfusions and salvage splenectomy. None of the patients revealed PBS patterns indicative of loss of splenic function (such as Howell-Jolly bodies) with a median follow-up period of 4.5 months. Two of our patients developed asymptomatic splenic infarction on postoperative imaging with a mean follow-up period of 6.6 months. Another patient had a left sub-diaphragmatic fluid collection, which became infected and necessitated ultrasound-guided catheter drainage.

Table 2. Comparison of study outcomes between overall and trauma patient sample

Variable	All patients (N=19)		Trauma patients (N=11)	
	Mean (S.D.)	p-value	Mean (S.D.)	p-value
Plt Increase=1	47.2 (16.70	0.95	41.8 (14.1)	0.68
Plt Increase=2	46.6 (21.0)		36.7 (23.9)	
WBC Increase=1	37.3 (23.1)	0.32	23.0(*)	0.34
WBC Increase=2	48.9 (17.0)		41.7 (17.5)	
Infection=1	57.0 (1.4)	0.01	**	
Infection=2	44.3 (18.9)		38.3 (17.4)	
Salvage Spleen=1	56.0 (3.0)	0.06	59 (*)	0.27
Salvage Spleen=2	44.2 (20.6)		35.1 (18.8)	

Discussion

The published success of splenic embolization in preventing splenectomy has ranged from 73 to 100%. Splenic embolization has been shown to not only increase the success rates of non-operative management but also extend the types of injuries, which can be managed non-operatively. The largest study of splenic embolization revealed an overall complication rate of 32% [14]. Half the patients with recurrent bleeding post-embolization required salvage splenectomy. The most common complication was splenic infarction; other complications included coil migration, arteriovenous fistulas, splenic artery dissections, and diaphragmatic and pancreatic injuries. In this study, only 3% of patients with infarcts went on to develop splenic abscesses. In comparison, the failure rate of splenic embolization in our cohort, as defined by the need for repeat embolization or surgery, was 21%. No variables were found to be significantly predictive of failure in this study.

Table 3. Outcomes in the trauma patient sample

Variable	Trauma Patients		p-value
	Female (%)	Male (%)	
Plt Increase=1	3 (60)	8 (62)	0.99
Plt Increase=2	2 (40)	5 (39)	
WBC Increase=1	1 (20)	2 (15)	0.99
WBC Increase=2	4 (80)	11 (85)	
Infection=1	1 (20)	1 (7)	0.47
Infection=2	4 (80)	13 (93)	
Salvage Spleen=1	1 (20)	2 (17)	0.99
Salvage Spleen=2	4 (80)	10 (83)	

The reviewed predictor variables in this study were age, gender, medical comorbidities, reason for embolization, choice of embolic material, and extent of embolization. The outcome variables were hemorrhage, infection, repeat embolization, salvage splenectomy, abnormal PBS, and splenic infarction. Our analyses did not reveal any statistically significant correlation between any of the predictor variables and any of the outcome variables. This could well be due to the small sample size of this study. An important finding, however, is that splenic embolization does not lead to loss of splenic function, as assessed by PBS examination. None of the 8 patients with post-embolization PBS examinations showed any abnormality indicative of asplenia. Three other patients had the PBS examination performed after salvage splenectomy and revealed patterns indicative of asplenia, such as Howell-Jolly bodies. In addition, only 2 out of the 19 patients in this study developed splenic infarction, when followed by a CT scan with a mean follow-up of 6.6 months.

One important aim of this study was to assess the likelihood of impairment of splenic function post TAE. This aspect of the procedure is often overlooked but is of most impor-

tance. The rationale for TAE to begin with is based, at least partially, on the desire to avoid asplenia with all its attendant sequelae, such as increased susceptibility to infections. Bessoud et al. documented the presence of splenic immune function in the majority of patients that underwent splenic embolization [15]. Their study, however, only assessed proximal, or main trunk, splenic artery embolization and is, therefore, not representative of the population of patients that undergo splenic embolization. Studies, suggest, in fact, that distal artery embolization may cause more splenic parenchymal injury than proximal embolization [16]. Whether this translates into higher rates of splenic function impairment is certainly possible but, as of yet, untested. In our study, 6 out of 19 patients underwent distal embolization without loss of splenic function.

In conclusion, our study demonstrates the preservation of splenic function (as determined on PBS examination) following splenic embolization. This preservation was noted regardless of the extent of embolization, material used for embolization, indication for embolization, and the patients' concomitant comorbidities and/or injuries.

Conflict of interest statement

The authors do not declare any conflict of interest or financial support in this study.

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