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Original Research Article

Experience with clinical pathway for management of high grade blunt splenic injuries: a prospective study in adults at two tertiary trauma centers

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ABSTRACT

Background: There is ambiguity regarding anatomical site of embolization, frequency of follow-up scans and splenic function following angioembolisation in the management of high grade blunt splenic injury. A splenic salvage pathway in patients who are hemodynamically stable or resuscitated to stability was introduced across two trauma centres. The aims of this project were: to develop a clinical pathway to manage hemodynamically stable blunt splenic injury patients and to determine rates of splenic salvage for patients with high grade splenic injury, assess complications and splenic function following completion of the pathway.
Methods: Prospective study over a period of 24 months. Data was collected to evaluate rates of splenic salvage, complications and function of the spleen following angioembolisation.
Results: Thirty-three patients, predominantly males (n=29) between the ages of 14-85 years, were included in the study. Three (9%) with grade V injury, underwent angioembolization on admission but required splenectomy as an inpatient. On day 14, all patients (n=30) with splenic salvage underwent blood tests, with 3 patients (9%) receiving vaccination for altered red cell morphology. The introduction of clinical pathway led to an increase in our splenic salvage rate to 91%.
Conclusions: We believe that introduction of proposed clinical pathway may result in increased rates of splenic salvage with preservation of function following angioembolisation.

Keywords: Spleen, Angioembolisation

INTRODUCTION

The spleen is an important organ of the immune system and is commonly injured in blunt abdominal trauma.[1] In 2012, The Eastern Association for the Surgery of Trauma published practice management guidelines for adult blunt splenic injury patients. These state "Nonoperative management of blunt adult splenic injuries is treatment modality of choice, irrespective of the grade of injury.[2]

In relation to non-operative management, there is ambiguity amongst trauma centres with respect to timing, frequency and mode of scanning, technique of embolization, frequency of follow-up imaging and the incidence of long-term complications.[3,4] This leads to a disparity in management between institutions making data difficult to collate and compare, ultimately resulting in poor utilisation of resources and an increase in hospital costs.[5] Additionally, availability of services can be

institution dependent adding complexity to the implementation of standardised guidelines.

Clinical pathways (CPWs) that are initiated locally provide a steppingstone to Clinical Practice Guidelines (CPGs). CPWs aim to organize and standardize care processes in order to optimise patient outcomes and improve organisational efficiency.[6,7]

In a recent retrospective review (2008-2018) of local data we found a 20% splenectomy rate for high grade splenic injuries. In response to this, we aimed to develop and pilot a clinical pathway for trauma patients with splenic injuries presenting at two Level I trauma centres. Following implementation of the pathway, we examined the data in relation to splenic salvage and complication rates of patients who had completed the pathway

Aims

The aims of this project were twofold:

To develop a clinical pathway to manage hemodynamically stable blunt splenic trauma patients.

To determine the rates of splenic salvage for patients with high grade splenic injury and assess complications and splenic function outcomes following completion of the pathway during this pilot phase.

METHODS

Design

A cross sectional cohort pragmatic design was used to determine the impact of the pilot phase of the pathway on the rates of splenic salvage following blunt injury.

Setting

The CPW was implemented at two tertiary referral trauma centres that accept patients aged 14 years old and upwards. The centres operate 5 days a week, with after-hours and weekend cover being provided by board certified surgeons with training in trauma care management. Both institutions attend to approximately 350 major trauma patients (Injury Severity Scale >12) annually. The interventional radiology unit is managed by a board-certified radiologist with capacity for out of hours cover. Both centres have high level Intensive Care Unit [ICU] capability to manage the severely injured patient.

Clinical pathway development

A CPW identifies an appropriate sequence of clinical interventions, timeframes, milestones and expected outcomes.[8] A multi-disciplinary team was established comprising of trauma surgeons, nurse practitioners, emergency room physicians, interventional radiologists and infectious disease consultants from both institutions. A literature search was undertaken to review the current evidence in management of hemodynamically stable blunt splenic injury patients; in addition, locally agreed clinical standard practices, based upon clinical expertise, experience and institutional capabilities were incorporated.

The local ethics committee deemed this project as Quality Improvement (QI) study.

The aim of this pathway was to reduce variation, improve the quality of care and maximise the splenic salvage rates for trauma patients.

Piloting clinical pathway development

A three- step clinical pathway was developed as depicted in Figure 1.

Admission computed tomography (CT) for trauma

All scans were performed with arterial phase helical acquisitions through their upper abdomen and portal venous phase helical acquisitions through the abdomen and pelvis. Tri planar reconstruction from the 1 mm slices was performed in every case and radiologist graded the splenic injury.

Contrast blush

Contrast blush was defined as active extravasation of contrast into the peritoneal cavity which might be associated with impending hemodynamic instability. The blush may not be demonstrated on either phase of the CT scan.[9] Contrast blush was a prerequisite for transfer to interventional radiology for formal angiography. Patients with high grade injuries (III-V) did not undergo immediate angiography in the absence of contrast blush.

Formal angiography

Formal angiography or digital subtraction angiography (DSA) was performed with one of two single plane Philips AluraClarity® floor mounted units with 48 cm image intensifiers. Angiography was always followed by embolisation. Embolization coils were selected according to the anatomy of the vessel and operator preference. Cook hilal, tornado and nester coils as well as Balt spirale coils and detachable concerto coils were deployed. In proximal embolization cases, a microvascular plug (MVP) (Medtronic®) was deployed before the coil depending on the operator preference. In no cases was a microvascular plug used alone.

Inpatient surveillance CT scan

Inpatient surveillance scan (performed on the same scanner as on admission) was carried out depending on the grade of original injury. High grade injuries (AAST IV/V) underwent scans at 48 hours and low grade (AAST III) at

72 hours. The duration from time of injury was selected as it would allow enough time for pathology (arterio-venous fistula/ pseudo aneurysm) of the vasculature or parenchyma to develop in setting of blunt injury. Patients who initially did not demonstrate contrast blush and developed pathology on subsequent imaging underwent inpatient angiography and embolization following the scan. Patients were then discharged 24hours after the procedure.

Assessment of splenic function

Splenic function was assessed in the out- patient department by reviewing red cell morphology on day 14 via a peripheral blood smear. This was supervised by board certified pathologist.[10] Red cell abnormality was defined by the presence of burr cells, Howell-Jolly bodies, stomatocytes, teardrops, agglutination, microcytes and sickle cells.[11] Day 14 was chosen as this duration provides adequate time for the inflammatory process from injury to settle.

Outpatient surveillance CT scan

Surveillance celiac axis- specific multi -phase CT of the abdomen was performed at the 6-month period to evaluate the effect of angioembolisation on the vasculature and parenchyma. This period was selected to allow adequate time for any evolving pathology of parenchyma or vasculature of the spleen following embolisation.

Inclusion criteria

All patients over 14 years of age who were hemodynamically stable or resuscitated by transfusion of appropriate products to hemodynamic stability following blunt abdominal injury with, AAST splenic injury grade III and above were included in the study.[12,13] Presence of other solid abdominal injury was not an exclusion criterion unless they underwent laparotomy for the management of the blunt abdominal injury.

Exclusion criteria

Hemodynamically unstable patients despite adequate resuscitation, penetrating injury to the spleen and patients younger than 14 years were excluded from the study.

Acute and delayed salvage

Salvage was defined as acute, if the patient had undergone embolisation immediately following admission to hospital and delayed if an evolving injury to the parenchyma or vasculature requiring interventional radiology intervention was identified on inpatient surveillance imaging.

Failure to salvage

Open splenectomy post- embolization as an inpatient was defined as failure to salvage.

Early and delayed splenectomy

The conventional definition of early (within 6 hours of injury) and delayed (post 6 hours of the injury) splenectomy as per literature was applied in this study.[14]

Adverse events / complications

Adverse events were defined by local and distant complications including; puncture site issues, splenic abscess formation, contrast- induced nephropathy and drainage of collections within the splenic parenchyma following angioembolisation.

Data collection

Patient demographical data including age, gender, injury and grade of splenic trauma was obtained from each centre's prospectively maintained trauma registry between January 2018 till December 2019. Time and anatomical site of embolization, inpatient surveillance computed tomography and delayed intervention either surgical or via intervention radiology was collected from the patient medical records. We also collected data for day 14 red cell morphology on peripheral blood film and outpatient surveillance CT imaging of the abdomen 6-months following embolization.

Data analysis

Descriptive statistics were used to analyse demographic data. Statistical analyses were performed using IBM Statistical package for social sciences (SPSS) Statistics for Windows [Version 24; SPSS Inc., Armonk, NY. IBM Corp]. Normally distributed continuous variables were described using mean [SD]. Where the data was not normally distributed, median values and inter quartile ranges [IQR] were reported. Categorical variables were summarised using counts and percentages.

RESULTS

During the twenty-four-month period thirty-eight patients presented with blunt splenic injuries. These patients were, predominantly males (n=29) with a median age of 36 years (IQR 14-85) and median ISS of 18 (IQR 5-38).

Five patients underwent early open splenectomy as they were hemodynamically unstable despite adequate resuscitation and were excluded from the study. Of the 33 patients, 15 had an AAST grade III splenic injury, 14 were diagnosed with grade IV and 4 with grade V splenic injuries.

Thirty patients underwent admission angiography and coiling for active contrast blush. Follow-up inpatient surveillance CT scan was not suggestive of any evolving pathology and hence these patients did not require another visit to the interventional radiology suite.

Three patients with grade IV injury, did not undergo angioembolisation on admission due to absence of contrast blush on admission CT scan. Follow-up inpatient surveillance CT scan identified evolving pathology; 2 patients developed arterio-venous fistulous communication near the hilum of spleen and were managed with angioembolisation. One patient developed a 2x1 cm pseudoaneurysm in the second level branch of splenic artery and was managed via catheter directed therapy. There were also several small PSA's (<0.5 cm) in the lower pole that were managed with observation.

Three patients with a median age of 36 years (25-54) and Grade V injury resuscitated to hemodynamic stability on admission, underwent non-selective angioembolization and Gelfoam (Gelfoam, Upjohn, Kalamazoo, MI) administration on admission but required delayed open splenectomy as an inpatient.

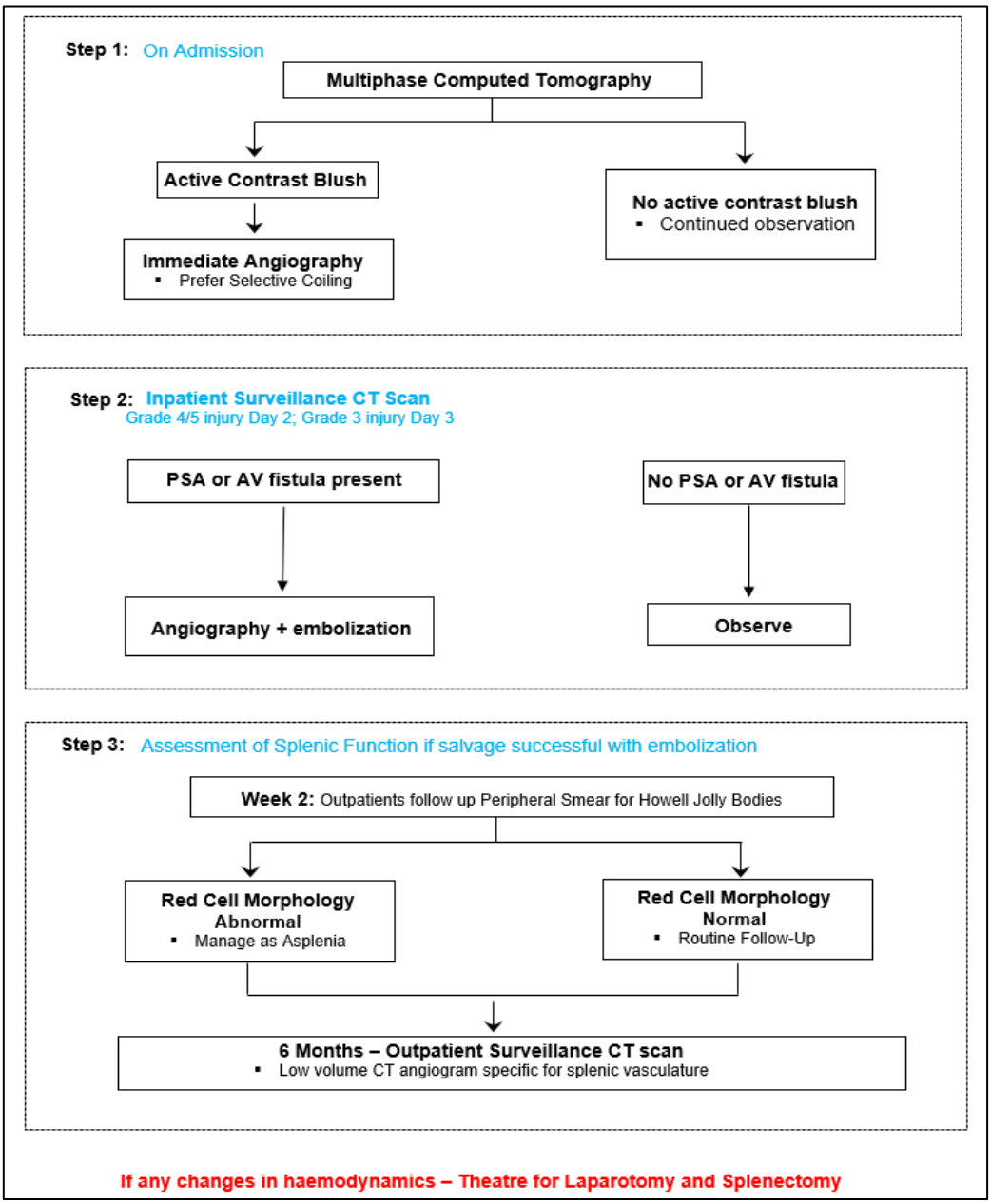

Figure 1: Clinical pathway for management of blunt splenic injuries.

Table 1: Demographics for resuscitation, coil placement and other haemostatic agent (number of patients).

Red Cell Transfusion prior to angioembolisation	Coil Placement -Proximal	Coil Placement - Distal	Additional Haemostatic agents (gelfoam)	Selective as well as non-selective embolization
8 (24%)	13 (39%)	23 (69%)	5 (15%)	2 (6%)

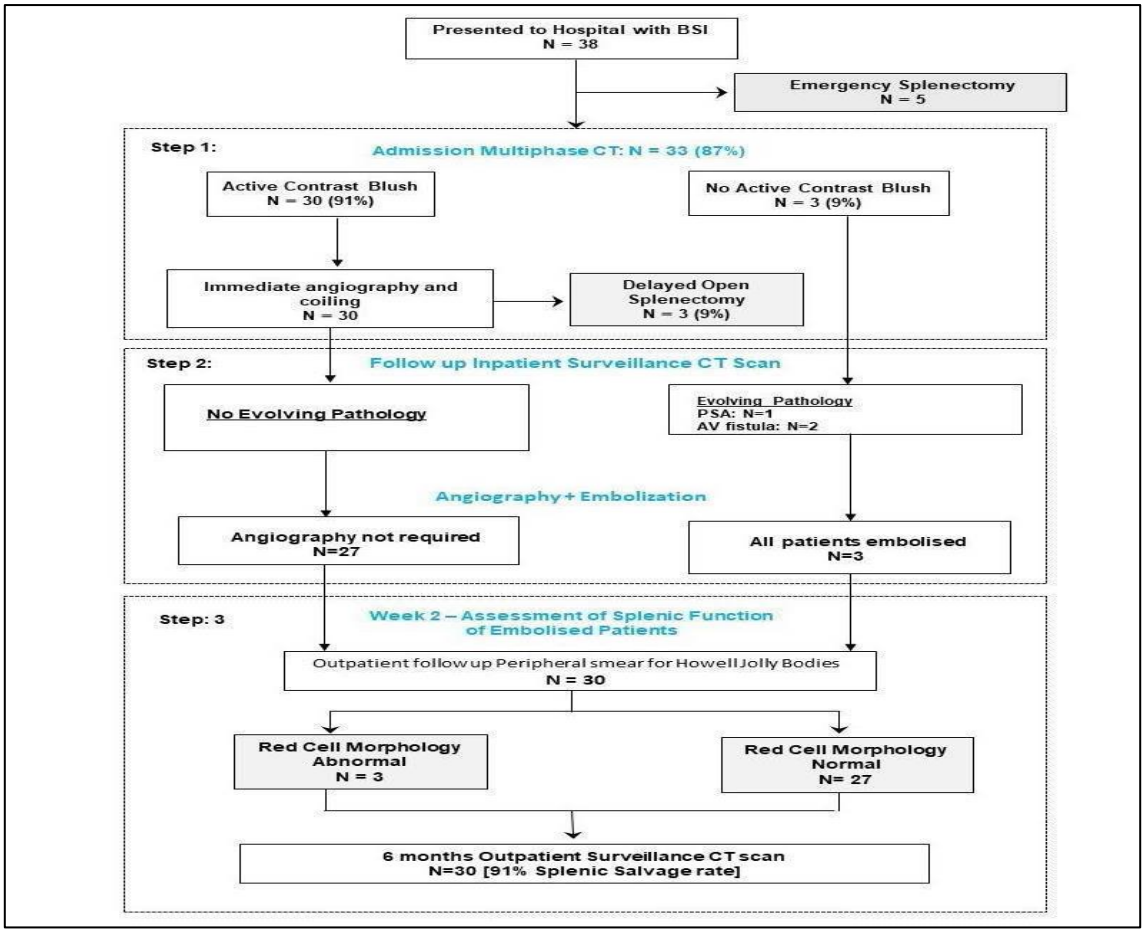

Figure 2: Outcomes of patients on clinical pathway.

The cause of splenectomy following angioembolisation in one case was due to new onset left sided pleural effusion leading to respiratory failure and non- invasive positive pressure ventilation in a patient with known cirrhosis of liver. Persistent transfusion requirement with abnormal arterial configuration not amenable to further attempts at angioembolisation was reason for splenectomy in the second case. The last patient was a known intravenous drug abuser who developed a splenic abscess following embolization and self-discharge from the hospital. The patient represented with a pneumoperitoneum secondary to rupture of the abscess requiring open splenectomy.

Figure 2 depicts the outcomes of patients whilst on the clinical pathway.

Table 1 depicts the demographics for resuscitation, coil placement and application of haemostatic agents.

There was no incident of patients undergoing angiography alone without the application of embolization coils.

Adverse events / complications

There were no puncture site or spleen- specific adverse events or mortality in the angioembolisation group.

Splenic salvage rate was 91%. This includes patients with diagnosed asplenia at day 14, none of these patients had splenectomy and showed good retention of contrast at 6 months on a surveillance CT scan.

14-day post injury red cell morphology blood test

On day 14, all 30 patients underwent an evaluation of splenic function via examination of red cell morphology on peripheral blood smear. Three patients demonstrated altered red cell morphology and required vaccination for presumed asplenia. All 3 patients were under the age of 30, had AAST grade IV injury and required more than 3 coils during angioembolisation.

Surveillance CT at 6 months, in all patients including 3 who had presumed asplenia on red cell morphology following salvage pathway did not demonstrate any altered pathology of parenchyma or vasculature of the embolised spleen.

DISCUSSION

The introduction of clinical pathway has led to an increase in our splenic salvage rate to 91%.

Three patients with grade V injuries underwent splenectomy following angioembolisation during their inpatient stay, 2 secondary to poor physiological reserve i.e. cirrhosis and intravenous drug abuse and one patient due to abnormal anatomy of the splenic vasculature not amenable to repeat angioembolisation.

Our pathway is conservative when compared to other trauma centres that follow straight- to -angiography suite policy for patients of high-grade splenic injuries15. The intervention for admission CT scan with contrast blush in our CPG was aimed at haemorrhage control. Hypotension, inaccurate timing for phase of scan, spasm of concerned arterial wall, resuscitation protocols and evolution of pathology in setting of blunt trauma are factors that make the admission CT scan unreliable.

Angiography on all patients with high grade injury as described in literature is not only invasive but does come with potential adverse events.[15] The inpatient surveillance scan not only allowed us to identify evolving pathology (arterio venous fistula/pseudoaneurysm) but also a single visit to angiography suite to manage the pathology. This might have contributed to absence of delayed splenic rupture in this series.

Literature review suggests various test for assessment of splenic function following embolization.[16,17] We carried out evaluation of red cell morphology to ascertain splenic function via a finger prick. This was conducted as; this is an easy test with no strain on the pathology or financial systems.

Use of particulate embolics and congenital variation amongst patients in the collateral blood supply to spleen may have contributed to ischemic changes to parenchyma resulting in reduced splenic function for 3 patients. The presumed functional asplenia necessitated vaccination to prevent overwhelming post splenectomy infection (OPSI) and increased susceptibility to infections via encapsulated organisms and influenza.[18-22] However, this avoided the need for an emergency exploratory laparotomy which would carry a risk of morbidity and mortality.[23] There was good retention of contrast medium at 6- month surveillance scan of all 3 patients with no pathology of the vasculature and parenchyma. The retention of contrast may be a sign of recovering splenic function following embolization.

Surveillance to evaluate ongoing pathology of the vasculature and parenchyma of the spleen following embolisation was done via CT scan. We are aware that contrast enhanced ultrasound (CEUS) is being used for surveillance as there is no risk of radiation. CEUS is not only operator dependent but is also difficult to interpret in some of our patient cohort due to their body habitus.[24]

The renewed AAST 2018 classification on splenic injuries include vascular injuries leading to upstaging of the injury.[25] This study was commenced prior to publication of the same, thus most of Grade III injuries in this series would have been upgraded to IV if renewed classification was applied.

Trauma care systems aim to reduce mortality and disability. Local and national change is associated with significant improvements in both the care process and outcomes of patients following severe injury.[26,27]

Our CPW is feasible and demonstrates improved patient outcomes in two similar Level I trauma centres. The information gained from this project will aid in the development of future Clinical Practice Guidelines which can be implemented more broadly to include different health settings and available resources. Clinical Practice Guidelines (CPG's) help healthcare professionals to improve the quality of care services whilst dealing with specific health-related condition.[28] These are statements which include recommendations to optimise patient care informed by a systematic review of evidence and an assessment of the benefits and harms of alternative care options.[29]

Limitations

The protocol utilised in this study may not be applicable across all centres due to institutional requirement for specific product guided resuscitation, dedicated trauma series CT scanner, surgeon as team leader, experienced interventional radiologist and availability of high dependency patient care unit with easy access to operating theatres. The number of patients recruited in this study is relatively small but provides a pilot for future studies with CPG implementation in a multi-centre study.

CONCLUSION

We believe that introduction of proposed clinical pathway may result in increased rates of splenic salvage with preservation of function following angioembolisation. Creation of a CPG and broader implementation will reduce disparity in the management of blunt splenic injuries.

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