PRACTICE MANAGEMENT GUIDELINES FOR

THE NONOPERATIVE MANAGEMENT OF BLUNT INJURY

TO THE LIVER AND SPLEEN

EAST Practice Management Guidelines Work Group

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I. Statement of the problem

Management of hepatic and splenic injuries has evolved over the past 25 years. Prior to that time, a diagnostic peritoneal lavage positive for blood was an indication for exploratory celiotomy because of concern about ongoing hemorrhage and/or missed intra-abdominal injuries needing repair. Stimulated by the success of nonoperative management of splenic and hepatic injuries in children who are hemodynamically stable, there has been a trend towards nonoperative management in hemodynamically stable adults with similar injuries.

Nonoperative management in children with splenic injuries rapidly gained currency because of the significant incidence and seriousness of post-splenectomy sepsis as well as the frequency of and complications associated with non-therapeutic laparotomies. More recently, nonoperative management has been extended to blunt hepatic injuries in children with similar success. Advantages of nonoperative management include avoidance of non-therapeutic celiotomies and the associated cost and morbidity, fewer intra-abdominal complications compared to operative repair, and reduced transfusion risks. Currently, nonoperative management of isolated blunt hepatic and splenic injuries is considered the standard of care for hemodynamically stable children.

The past five years have witnessed a proliferation of reports of nonoperative management in adults with injuries to the liver and spleen. However, it is unclear whether the pediatric experience is generalizable to adults.

The majority of these reports support nonoperative management in hemodynamically stable adults, but uncertainty still exists about efficacy, patient selection, and details of management. Is nonoperative management appropriate for all hemodynamically stable adults regardless of severity of solid organ injury or presence of associated injuries? Is the risk of missing a hollow viscus injury a deterrent to nonoperative management? What is the best way to diagnose injury to the liver or spleen? What role does CT and/or ultrasound have in the hospital management of the patient being managed nonoperatively? Is the need for transfusion greater in patients managed nonoperatively? And finally, should patients be kept on bedrest, and if so, how long?

II. Process

A. Identification of references

References were identified using the computerized searched of the National Library of Medicine (NLM) using the NLM's search service to access Medline. The search was designed to identify English language citations between 1976 and 1996 using the keywords: splenic injury; liver injury; intestinal injury; and blunt abdominal trauma. The bibliographies of the selected references were examined to identify relevant articles not identified by the computerized search. One hundred forty-five articles were identified. Literature reviews, case reports, and editorials were excluded. A cohort of seven trauma surgeons selected 120 articles for review and analysis.

B. Quality of references

The methodology developed by the Agency for Health Care Policy and Research (AHCPR) of the United States Department of Health and Human Services was used to group the references into three classes.

Class I: prospective randomized studies
Class II: prospective, non-comparative studies; retrospective series with controls
Class III: retrospective analyses (case series, databases or registries, case reviews)

Based on the review and assessment of the selected references, three levels of recommendations are proposed.

Level I: Convincingly justifiable on scientific evidence alone – based on class I data.

Level II: Reasonably justifiable by available scientific evidence and strongly supported by expert opinion – supported by class I or class II data.

Level III: Adequate scientific evidence is lacking but widely supported by available data and expert opinion – supported by class II or class III data.

III. Recommendations

A. Level I

There are insufficient data to suggest nonoperative management as a Level I recommendation for the initial management of blunt injuries to the liver and/or spleen in the hemodynamically stable patient.

B. Level II

1. There are class II and mostly class III data to suggest that nonoperative management of blunt hepatic and/or splenic injuries in a hemodynamically stable patient is reasonable.

2. The severity of hepatic or splenic injury (as suggested by CT grade or degree of hemoperitoneum), neurologic status, and/or the presence of associated injuries are not contraindications to nonoperative management.

3. Abdominal CT is the most reliable method to identify and assess the severity of the injury to the spleen or liver.

C. Level III

1. The clinical status of the patient should dictate the frequency of follow-up scans.

2. Initial CT of the abdomen should be performed with oral and intravenous contrast to facilitate the diagnosis of hollow viscus injuries.

3. Medical clearance to resume normal activity status should be based on evidence of healing.

4. Angiographic embolization is an adjunct in the nonoperative management of the hemodynamically stable patient with hepatic and splenic injuries and evidence of ongoing bleeding.

IV. Scientific Foundation

A. Diagnosis of blunt injury to the liver or spleen

Scintigraphy,[9,30,70,82,85,92] DPL,[19,21-26] CT,[7-13,21,25-27] laparoscopy,[1-6,24] and ultrasound[9,14-20,26,27] have been employed to diagnose blunt injuries to the liver and spleen. Of these modalities, CT scan is the most accurate, specific, and sensitive in delineating the extent and severity of injury.[5,7-12,26] Additionally, the CT scan can evaluate the retroperitoneum for presence of injuries.[21,27]

Oral and intravenous contrast may enhance the utility of CT scans to identify hollow viscus injuries.[105,114]

B. Nonoperative management

1. Efficacy

The literature search identified 73 articles specifically addressing the efficacy of nonoperative management of hepatic and/or splenic injuries.[30-51,53-103] With the exception of two recent

prospective studies (class II),[46,48] all studies were class III reports. Sixty-six of these 72 studies concluded that nonoperative management was appropriate for selected hemodynamically stable patients. With one exception,[97] all the reports which demurred were published prior to 1990.[80,83,84,89,97] The term "selected" varied greatly among the studies, with early reports largely more conservative in criteria for nonoperative management.[3,33,38,41,51,52,65,70,71,94,98] Typically in those studies, patients with isolated solid organ injuries of lower severity and smaller amounts of hemoperitoneum were selected for nonoperative management. The more recent reports, specifically the two recent class II studies,[46,48] broadened the selection criteria to include patients with other intra-abdominal injuries not requiring operation,[48,53,54] extra-abdominal injuries,[45,46,48,54] head injuries,[42,48,56,59] higher grades of hepatic or splenic injury,[43-46,48,57] and older patients.[46,48] On this point, two class III reports[91,100] suggest that patients older than 50 to 60 years of age with splenic injuries are more likely to fail nonoperative management and also are at greater risk for nonoperative related complications.[100]

Neither grade of injury nor degree of hemoperitoneum on CT predict the outcome of nonoperative management. Clearly, the hemodynamic status of the patient is the most reliable criteria for nonoperative management.[40,45,48,49,67,101,102] The presence of a contrast blush on the vascular phase of the CT examination of the spleen may portend failure of nonoperative management.[103]

As more clearly emphasized in the recent studies, nonoperative management does not carry with it a greater need for transfusion than operative management.[46,48,57,74,75] Indeed, several studies suggest that the need for transfusion is less with nonoperative management than it is with operative management for injuries of similar grades.[75,96]

The two class II reports suggest that nonoperative management of hepatic injuries has fewer liver-related and intra-abdominal complications than operative management.[46,48]

2. Angiography

Angiography and embolization have been successfully employed and its use suggested to control ongoing hemorrhage in the hemodynamically stable patient.[37,43,44,60,63]

3. Pathologic Spleen

Of note, nonoperative management has been successfully used in 12 patients with injured pathologic spleens.[116,118] Potential problems with this approach are detailed in a contemporary case series of four patients undergoing splenectomy for mononucleosis-associated splenic injury.[117]

4. Follow-up evaluations

Though often practiced and reported, there is no evidence that serial abdominal CT scans without clinical indications influenced either the outcome or the management of the patient.[10,46,50,64] Likewise, there is no evidence that bedrest or restricted activity is necessary or beneficial.[45,48]

5. Hollow viscus injuries

The early concerns[80] over hollow viscus injuries are not substantiated by the reported incidence of bowel perforations associated with or missed by nonoperative management.[43,44,48,65,74,94,104-115]

6. Activity

Prior to resuming normal activity, there should be evidence of healing of the injury.[32,45,46,48,71,82,91] Time to complete healing of splenic and liver injuries varies with the extent and severity of injury.[32,45,76,78,79]

7. Late hemorrhage

Late fatal hemorrhage has occurred after nonoperative management of the liver.[119] Delayed hemorrhage has occurred with rupture of a splenic artery pseudoaneurysm.[120]

V. Summary

Nonoperative management of blunt adult and pediatric hepatic and splenic injuries is the treatment modality of choice in hemodynamically stable patients, irrespective of the grade of injury. It is associated with a low overall morbidity and mortality and does not result in increases in length of stay, need for blood transfusions, bleeding complications, or visceral associated hollow viscus injuries as compared with operative management. There is no evidence supporting routine imaging (CT or US) of the hospitalized, clinically improving, hemodynamically stable patient. Nor is there evidence to support the practice of keeping the clinically stable patient at bedrest.

Finally, angiographic embolization is a useful adjunct in nonoperative management of the hemodynamically stable patients who continues to bleed.

VI. Future Investigation

Topics for future studies include:

A. Cost analysis of operative vs. nonoperative management.

B. Evaluation of the cost benefit analysis of the radiologic evaluation of hepatic and splenic injuries.

C. Use and development of clinical, radiologic, laboratory, hemodynamic parameters to identify patients warranting arrangement in the intensive care setting.

VII. References

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NONOPERATIVE MANAGEMENT OF SOLID ORGAN INJURY: EVIDENTIARY TABLES

First Author	Year	Reference Title	Class	Conclusions
Gazzaniga AB	1976	Laparoscopy in the diagnosis of blunt and penetrating injuries to the abdomen. *Am J Surg 131:315-318*	III	Early study of 132 patients with blunt & penetrating abdominal injury; 32 had laparoscopy. Hemoperitoneum was over-estimated by laparoscopy. Retroperitoneal injuries were difficult to diagnose. If remaining 118 patients had laparoscopy first, 21% of laparotomies could have been avoided.
Carnevale N	1977	Peritoneoscopy as an aid in the diagnosis of abdominal trauma: A preliminary report. *J Trauma 17:634-641*	III	20 abdominal trauma patients judged to require xlap had laparoscopy in OR prior to laparotomy. Laparotomy was avoided in 12 of 20.
Livingston DH	1992	The role of laparoscopy in abdominal trauma. *J Trauma 33:471-475*	II	39 stable trauma patients (blunt & stab wounds) were prospectively evaluated by laparoscopy prior to celiotomy. At laparoscopy, there was difficulty in viewing spleen & determining amount of hemoperitoneum. Small bowel injury was missed. 11 patients had no injury detected on laparoscopy; this was confirmed by celiotomy. Limitations: used 0^{o} scope and no advanced equipment.
Salvino CK	1993	The role of diagnostic laparoscopy in the management of trauma patients: A preliminary assessment. *J Trauma 34:506-515*	II	75 patients with blunt injury or stab wounds were evaluated by laparoscopy prior to DPL. There was no diagnostic advantage in blunt trauma patients. Laparoscopy documented 3 diaphragmatic injuries in patients with stab wounds. Laparoscopy for evaluation of (+) DPL would decrease nontherapeutic laparotomy rate by 33%.
Townsend MC	1993	Diagnostic laparoscopy as an adjunct to selective conservative management of solid organ injuries after blunt abdominal trauma. *J Trauma 35:647-653*	II	Prospective study of 115 patients with solid organ injuries identified by CT scan. Investigated efficacy of diagnostic laparoscopy as adjunct in patient selection for conservative therapy. 15/17 solid organ injuries were identified by laparoscopy. Occult hollow viscus injury was found in 2 patients who required laparotomy. Therapeutic laparotomy for solid organ injury was required in 5 additional patients due to ongoing hemorrhage (4) or poor visualization (1) on laparoscopy. In this small study, diagnostic laparoscopy was an effective tool in diagnosing solid and hollow organ injuries and selecting patients for conservative treatment.
Brandt CP	1994	Potential of laparoscopy to reduce non-therapeutic trauma laparotomies. *Am Surg 60:416-420*	II	Prospective study of laparoscopy performed prior to laparotomy in 21 patients with blunt (10) & penetrating (11) abdominal trauma & hemodynamic instability. Laparoscopy helped to accurately predict therapeutic laparotomy in 100% of 12 cases, non-therapeutic laparotomy in 6, negative laparotomy in 3. Laparotomy missed 53% of specific injuries, most commonly splenic injury. Conclude that laparoscopy could reduce non-therapeutic laparotomy rate. Advocate for stable patients sustaining blunt trauma, anterior abdominal stab wounds, or tangential penetrating injuries that have standard indications for laparotomy.

First Author	Year	Reference Title	Class	Conclusions
Jeffrey RB	1981	Computed tomography of splenic trauma. *Radiology 141:729-732*	III	Retrospective review of 50 patients with left upper quadrant trauma (47 blunt, 3 penetrating). 27 patients had no CT evidence of splenic injury [confirmed by operation (1) & clinical follow-up (26)]. 21/22 (96%) surgically proven splenic injuries were found by CT. 1 splenic laceration was missed due to motion artifacts & streaking. 5 other clinically significant abdominal injuries were identified by CT. CT was felt to be an accurate non-invasive method of rapidly diagnosing splenic trauma and associated injuries.
Federle MP	1982	Computed tomography in blunt abdominal trauma. *Arch Surg 117:645-650*	III	Early study of 200 patients with blunt mechanism & CT evaluation. CT diagnosis of solid organ & retroperitoneal injuries was reliable. No false (+) or false (-) studies. Recommended for stable patients with unreliable exams or suspicion of intra-abdominal _____.
Kaufman RA	1984	Upper abdominal trauma in children: Imaging evaluation. *AJR Am J Roentgenol 142:449-460*	II	Prospective study of 100 consecutive children. 95 hemodynamically stable patients underwent CT imaging compared to liver spleen scintigraphy & sonography. 52 patients (55%) had all 3 studies & 67 patients had CT & scintigraphy. CT had fewer false (-) & false (+) than scintigraphy or sonography. False (-) rate = 50% for sonography in diagnosing splenic injuries.
Goldstein AS	1985	The diagnostic superiority of computerized tomography. *J Trauma 25:938-946*	III	100 patients with blunt trauma had CT either before or after DPL. 16/42 patients with (-) DPL had 22 injuries identified by CT. 17/85 patients with hematuria had GU abnormalities identified by CT. No significant injuries were missed by CT. Valuable tool for evaluation of stable patients with blunt abdominal injury.
Federle MP	1987	Splenic trauma: Evaluation with CT. *Radiology 162:69-71*	III	Of 210 splenic injuries diagnosed at surgery, 55 underwent preop CT. CT accurately diagnosed splenic injury in 54. In the 1 false (-), CT correctly indicated presence of large hemoperitoneum requiring surgery. Emphasized importance of CT in distinguishing perisplenic clot (suggesting splenic injury) from lysed blood within peritoneum. CT was found to be highly reliable in this study.
Taylor GA	1988	The role of computed tomography in blunt abdominal trauma in children. *J Trauma 28:1660-1664*	III	Retrospective study of 343 stable children with blunt abdominal trauma. 84 had (+) CT & 9 required surgery; 6 had large hemoperitoneum. Most were solid organ injuries. Conclude decision for laparotomy should be based on physiologic status of child.
Meyer DM	1993	Computed tomography in the evaluation of children with blunt abdominal trauma. *Ann Surg 217:272-276*	II	60 hemodynamically stable children with blunt mechanism were evaluated by CT prior to DPL. Operation based on (+) CT or DPL. CT missed 2 pancreatic & 2 GI injuries. 2% non-therapeutic laparotomy rate. Conclude DPL better. Many "therapeutic" laps were drainage or repair of non-bleeding lesion.

First Author	Year	Reference Title	Class	Conclusions
Kimura A	1991	Emergency center ultrasonography in the evaluation of hemoperitoneum: A prospective study. *J Trauma 31:20-23*	III	Prospective study of 72 patients with blunt abdominal trauma evaluated for presence of hemoperitoneum with US. Sensitivity-86.7%, specificity-100%, accuracy-97.2% in detecting hemoperitoneum. Limitations:all cases not confirmed with another diagnostic modality, ie CT or DPL; when CT or DPL was used, specific cases were not identified; method of diagnosis of solid organ injuries was not noted.

Tso P	1992	Sonography in blunt abdominal trauma: A pre-liminary progress report. *J Trauma 33:39-44*	II	163 stable patients evaluated by US prior to DPL/CT. US identified all clinically significant hemoperitoneum (sensitivity= 91%).
Bode PJ	1993	Abdominal ultrasound as a reliable indicator for conclusive laparotomy in blunt abdominal trauma. *J Trauma 34:27-31*	III	353 blunt abdominal trauma patients evaluated with US by radiologist. Indications for laparotomy: large amount of intra-abdominal fluid; fluid with solid organ injury; increasing amount of fluid. US=93% specific, 99% accurate for these criteria. No non-therapeutic laparotomies.
Rothlin MA	1993	Ultrasound in blunt abdominal and thoracic trauma. *J Trauma 34:488-495*	II	290 blunt trauma patients had US in ER by surgeon; 90% sensitive, 99% specific for IA injury. US was better identifying free fluid compared to solid organ injury. US is noninvasive, fast, & repeatable.
Branney SW	1997	Ultrasound based key clinical pathway reduces the use of hospital resources for the evaluation of blunt abdominal trauma. *J Trauma 42:1086-1090*	II	Prospective data over 3-months evaluating clinical pathway for blunt abdominal trauma. US done in ER. # CT/DPL decreased with these studies used in patients with more significant injury. 65% of patients had no other studies. # admissions for observation significantly decreased. No significant injury was missed.
Boulanger BR	1996	Emergent abdominal sonography as a screening test in a new diagnostic algorithm for blunt trauma. *J Trauma 40:867-874*	II	Prospective study compared emergent abdominal US to DPL/CT. In 400 patients with blunt trauma, US was performed 1st then followed by CT (293) or DPL (107). US accuracy for diagnosis of free fluid=94% with (+) and (-) predictive values of 82% & 96%, respectively. Did not attempt to identify specific organ injuries. US was done by clinicians & 82% were done in <3 minutes. 21/293 patients (7%) had solid organ injuries on CT but no free fluid on CT/US. None required laparotomy during hospital stay. Conclude: emergent US done by clinicians was accurate test of free fluid & patients with (-) US should have close follow-up.
Akgur FM	1997	Prospective study investigating routine usage of ultrasonography as the initial diagnostic modality for the evaluation of children sustaining blunt abdominal trauma. *J Trauma 42:626-628*	II	Prospective study of 217 children who had US exams by radiologist in ER. 60 had (+) studies; all had CT that added info in only 3 cases. No change in management plan.
Marx JA	1985	Limitations of computed tomography in the evaluation of acute abdominal trauma: A prospective comparison with diagnostic peritoneal lavage. *J Trauma 25:933-937*	II	Prospective study of 100 consecutive patients with hepatic injury from blunt & stab mechanisms. CT was done prior to DPL. CT sensitivity=25%. CT missed several significant intra-abdominal injuries (free blood & solid organ injury). CT may have advantages for retroperitoneal injuries. Very atypical results for CT compared to present technology.

First Author	**Year**	**Reference Title**	**Class**	**Conclusions**
Fabian TC	1986	A prospective study of 91 patients undergoing both computed tomography and peritoneal lavage following blunt abdominal trauma. *J Trauma 26:602-608*	II	Prospective study with 91 control patients. Patients had CT follow-ed by DPL. CT not always evaluated by experienced tomographers. Initial CT reading had accuracy=69%. CT read by experienced tomographer was as good as DPL but more expensive. No perceived diagnostic advantage for CT over DPL.
Rothenberg S	1987	Selective management of blunt abdominal trauma in children–the triage role of peritoneal lavage. *J Trauma 27:1101-1106*	III	Retrospective review of 46 children with DPL for abdominal trauma. 16 were (+), 6 had therapeutic laps. Based on this data, laparotomy recommended only if DPL was (+) for blood & patient was not hemodynamically stable, or DPL (+) for bile or food material. Stable child with (+) DPL had CT/L-S scan. Reduced unnecessary laparotomy from 37.5% to 18%. Selective laparotomy policy based on DPL.

Cuschieri A	1988	Diagnosis of significant abdominal trauma after road traffic accidents: Preliminary results of a multicenter clinical trial comparing mini-laparoscopy with peritoneal lavage. *Ann R Coll Surg Engl 70:153-155*	I	Randomized, prospective trial with 55 patients enrolled thus far. All patients underwent minilaparoscopy prior to DPL. Both were sensitive for detection of IA injury but nontherapeutic laparotomy was higher for DPL.
Meyer DM	1989	Evaluation of computed tomography and diagnostic peritoneal lavage in blunt abdominal trauma. *J Trauma 29:1168-1172*	II	301 stable blunt trauma patients with equivocal exams had CT followed by DPL. 19 had (-) CT with (+) DPL and significant injury at celiotomy. DPL continues to be reliable with 96% sensitivity & 99% specificity.
Liu M	1993	Prospective comparison of diagnostic peritoneal lavage, computed tomographic scanning, and ultrasonography for the diagnosis of blunt abdominal trauma. *J Trauma 35:267-270*		Prospective study of 55 stable patients with blunt abdominal trauma. Patients underwent both CT & US then DPL. Any (+) result led to laparotomy. Sensitivity, specificity, & accuracy: DPL-100%, 84.2%, 94.5%; CT-97.2%, 94.7%, 96.4%; US-91.7%, 94.7%, 92.7%. Note that tests were complimentary & should be combined with frequent clinical exams. 3 intestinal perforations were missed by US.
Katz S	1996	Can ultrasonography replace computed tomography in the initial assessment of children with blunt abdominal trauma? *J Pediatr Surg 31:649-651*	II	124 children with blunt abdominal trauma evaluated by US in ER. US (+) predictive value=55%, (-) predictive value=99%. US very accurate in identifying free fluid. 78% had (-) US and no further evaluation without missed injury. 28 children had (+) US; 10 injuries confirmed by CT, 8 had normal CT. US is efficient modality for evaluation of blunt abdominal trauma.

First Author	Year	Reference Title	Class	Conclusions
Meyer AA	1985	Selective nonoperative management of blunt liver injury using computed tomography. *Arch Surg 120:550-554*	III	24 patients with limited parenchymal liver injury & <250ml of peritoneal blood noted on CT had nonoperative management. Admission systolic BP was >90mmHg in all patients. No patient required laparotomy or had complication of liver injury. 4 patients had severe CHI & 2 of these died of their CHI with no complications of liver injury. Recommended selection criteria: (1) patient should be hemodynamically stable with no peritoneal signs/indications for laparotomy; (2) CT should be good quality & interpreted by physician experienced in reading CTs for trauma; limited liver injury should be present; (3) decision for nonoperative management should be made by physician experienced in trauma; (4) patients should be monitored closely for bleeding or other complications; (5) institution should have resources & personnel to perform surgery immediately if needed.
Ciraulo DL	1996	Clinical analysis of the utility of repeat computed tomographic scan before discharge in blunt hepatic injury. *J Trauma 41:821-824*	III	Review of CT scans of 95 patients with hepatic injuries managed nonoperatively. Patients were grouped based on grade of injury & subgroups divided based on whether 1 or more CT were done. Follow-up CT did not alter treatment. Suggest routine practice can be safely abandoned & lead to reduction in health care cost.
Cywes S	1985	Blunt liver trauma in children: Nonoperative management. *J Pediatr Surg 20:14-18*	III	Retrospective review of 19 patients successfully treated nonoperatively. Injuries diagnosed by CT/liver isotope scans. Follow-up with US at monthly intervals. No complications in series. CT & follow-up US scans were reliable.
Vock P	1986	Blunt liver trauma in children: The role of computed tomography in diagnosis and treatment. *J Pediatr Surg 21:413-418*	III	8/12 children with blunt liver trauma required operation, 4 had successful non-operative management. CT results correlated well with surgical findings. Other organ injuries were identified on CT in 6 patients. CT was useful imaging method.
Bulas DI	1993	Hepatic injury from blunt trauma in children: Follow-up evaluation with CT. *AJR Am J Roentgenol 160:347-351*	III	45 children with CT or surgical evidence of hepatic injury were followed clinically & with serial CT. All mild hepatic injuries (<24% of 1 lobe or isolated subcapsular hematoma) appeared to heal on follow-up CT done 1 week-11 months post injury. 67% of moderate hepatic injuries (25-50% of 1 lobe) showed complete healing 1-3 months post injury (80% between 3.5-6 months). Severe injuries (>50% of 1 lobe or bi-lobar) had residual injuries up to 8 months post injury. CT grading appeared useful for establishing time course of healing.
Farnell MB	1988	Nonoperative management of blunt hepatic trauma in adults. *Surgery 104:748-756*	III	Review of 20/66 hemodynamically stable patients with blunt hepatic trauma treated by initial nonoperative therapy, with no peritoneal irrigation. CT criteria for nonoperative management included contained subcapsular hematoma, unilobar fracture, absence of devitalized liver, minimal intraperitoneal blood, & absence of other significant intra-abdominal organ injuries. 2 patients failed nonoperative management & 1 patient with severe head injury & minor liver laceration expired as a result of the head injury.

First Author	Year	Reference Title	Class	Conclusions

Scatamacchia SA	1989	Splenic trauma in adults: Impact of CT grading on management. *Radiology 171:725-729*	II	Combined retrospective & prospective study to determine efficacy & safety of CT grading of splenic injury. Splenic scoring was dependent on parenchymal injury & hemoperitoneum. Scores ranged from 0-6. Retrospective data: 29 patients (operative vs nonoperative scores, 3.8 vs 1.9) & prospective data: 35 patients (4.1 vs 1.7, respectively). Retrospective data analysis=scores <2.5 could be treated nonoperatively. Operative rate did not change in prospective study using this analysis, but splenorrhaphy rate improved from 21% to 67%.
Federico JA	1990	Blunt hepatic trauma. Nonoperative management in adults. *Arch Surg 125:905-909*	III	Case series. 16/56 patients with blunt hepatic injury managed nonoperatively. No delayed laparotomies or deaths. 50% required transfusion not exceeding 3 units. Amount of fluid in abdomen did not predict failure of treatment.
Hammond JC	1992	Nonoperative management of adult blunt hepatic trauma in a municipal trauma center. *Am Surg 58:551-556*	III	Case series analysis, 7 years. 20 patients managed nonoperatively for blunt hepatic injury. Represented 20/56 (35.7% of all patients with blunt hepatic injury). Nonoperative management successful in 95%. Mortality 0%, morbidity 0%. No early or late intra-abdominal complications noted.
Foley WD	1987	Treatment of blunt hepatic injuries: Role of CT. *Radiology 164:635-638*	III	Retrospective review of 20 patients treated conservatively for hepatic injuries with serial upper abdominal CT scans. 14 patients had associated hemoperitoneum & resolution was noted on follow-up CT (performed usually within 1 week) in all but 1 patient who developed shock requiring laparotomy & ligation of bleeding middle hepatic vein. CT was useful adjunct. Recommend consideration of angiography with embolization or laparotomy in patients when resorption of intraperitoneal hemorrhage is not documented on follow-up CT.
Mirvis SE	1989	Blunt hepatic trauma in adults: CT-based classification and correlation with prognosis and treatment. *Radiology 171:27-32*	III	37/187 patients retrospectively reviewed for hepatic injury had liver injury as principal site of injury on CT before surgery. 31 (83.7%) successfully treated nonoperatively. 4 other patients (10.8%) had findings at celiotomy that required no further surgery. CT-based grading system (1-5) was useful in predicting outcome. Patients with associated major intra-abdominal organ injuries were excluded, limiting application of grading system to isolated liver injuries.
Hiatt JR	1990	Nonoperative management of major blunt liver injury with hemoperitoneum. *Arch Surg 125:101-103*	III	16/68 patients successfully managed nonoperatively for blunt hepatic injury. 2 patients received non-therapeutic laparotomies.
Hollands MJ	1991	Non-operative management of blunt liver injuries. *Br J Surg 78:968-972*		Case series (1979-89) analysis. Patients grouped: I-Nonoperative; II-Operative; III-Operative, non-therapeutic. Nonoperative management criteria: (1) ease of resuscitation; (2) hemodynamic stability for 4-6 hours; (3) no ongoing transfusion requirements. Patients managed nonoperatively were less likely to be in shock, had less severe CT grade of injury, younger in age. Cardiovascular status & abdominal exam, not CT grade of injury, are basis to determine nonoperative or operative management. 30% of operative group had non-therapeutic laps.
First Author	**Year**	**Reference Title**	**Class**	**Conclusions**

Durham RM	1992	Management of blunt hepatic injuries. *Am J Surg 164:477-481*	III	Purpose: to define criteria for nonoperative management of liver injuries. Case series analysis of 63 patients with blunt liver injury (1986-91). Nonoperative management of liver injury indicated in patients who are hemodynamically stable with no associated injuries requiring operation. CT underestimates grade of liver injury, particularly in centrally located injuries. Large amount of intraperitoneal blood, CT grade=IV or V, need for >2 units of blood during initial resuscitation are considerations for operation. Follow-up CT 5-7 days after injury recommended.
Bynoe RP	1992	Complications of nonoperative manage-ment of blunt hepatic injuries. *J Trauma 32:308-315*	III	Case series: 26 patients with blunt hepatic injury managed nonoperatively. 5 (19%) developed complications: 2 bowel leaks (operative repair), 3 subcapsular hematomas.
Pachter HL	1992	Significant trends in the treatment of hepatic trauma. Experience with 411 injuries. *Ann Surg 215:492-502*	III	Case series: 13 multicenter Level I trauma centers. 404 patients. AAST grading scale:I-19%; II-31%; III-36%; IV-10%; V-4%. Inclusion criteria: hemodynamic stability after moderate fluid infusion; no peritoneal signs; CT scan; no associated injuries needing urgent surgery; no excessive blood transfusions. Variables measured were AAST grade, CT follow-up, length of stay, transfusions, mortality, & complications. Results: 14% were grade IV or V (66% of failures had grade IV or V). CT done after 7 days more likely to show improvement. Length of stay varied. 89% of patients did not need transfusions. Those transfused had multiple associated injuries. Mortality was 7%; 60% due to head injury & 2 deaths attributed to hepatic injury. 5% complication rate: 2 hemorrhage; 2 biloma; 3 perihepatic abscess; 2 hollow viscus injuries. Conclusions: nonoperative management of liver injury is successful in 98.5% without excessive transfusions. Missed hollow viscus injuries in 0.5%. Angiographic embolization suggested as approach to hemodynamically stable patient with ongoing hemorrhage on CT. CT documentation that injury is improving is useful. Hemodynamic instability mandates operative intervention.
Meredith JW	1994	Nonoperative management of blunt hepatic trauma: The exception or the rule? *J Trauma 36:529-535*	III	Case series analysis of blunt liver injuries to determine which patients with blunt hepatic injury should be managed nonoperatively. 16 patients underwent surgery or nonoperative management. 70/72 were successfully managed nonoperatively; 2 patients explored had non-therapeutic laps. Patients managed nonoperatively did not require significantly more blood transfusions. Grade of injury did not predict need for surgery. No missed bowel or retroperitoneal injuries. Routine follow-up scans did not influence patient management & were abandoned as routine practice in absence of clinical indications. Conclude nonoperative management of blunt hepatic injury based on hemodynamic stability, absence of peritoneal signs, lack of other associated abdominal injuries requiring operation is safe.

First Author	**Year**	**Reference Title**	**Class**	**Conclusions**

Sherman HF	1994	Nonoperative management of blunt hepatic injuries: Safe at any grade? *J Trauma 37:616-621*	II	Prospective cohort study of patients with blunt hepatic injury confirmed by CT & admitted to trauma center. Exclusion criteria: hemodynamic instability not responding to fluid resuscitation; other injuries requiring laparotomy; patient unavailable for control monitoring. Comparison group: patients having surgery for blunt hepatic injury. 60 patients evaluated: 30 nonoperatively, 30 operatively. Hemodynamic stability can be used safely & effectively to manage blunt hepatic injury. Nonoperative & operative groups were comparable re: age, sex, ISS & # of extra-abdominal injuries. Non-operative group had more severe blunt hepatic injury yet required fewer transfusions. Routine scans had little impact on clinical management. CT should be obtained at minimal time necessary for healing.
Boone DC	1995	Evolution of management of major hepatic trauma: Identification of patterns of injury. *J Trauma 39:344-350*	III	Case series. Entry criteria: hemodynamic stability with no ongoing resuscitation fluid needs. Most stable enough to have CT can be managed nonoperatively. No increased morbidity or mortality compared to operative management. Injury to posterior segment of right lobe and split liver usually are relatively stable. Left hepatic lobe injuries are mor complex and deep. No missed intra-abdominal injuries in this series.
Croce MA	1995	Nonoperative management of blunt hepatic trauma is the treatment of choice for hemodynamically stable patients. Results of a prospective trial. *Ann Surg 221:744-755*	II	Prospective cohort study with historical controls >22 months in regional trauma center. Variables measured: blunt hepatic injury + CT grading + amount of hemoperitoneum (minimal, moderate, large). 112 study population nonoperative management. Grade IV-V in 38%. No hepatic related mortality. Blood in peritoneal cavity (per CT) correlated with CT grade of injury. 89% were successfully managed nonoperatively. Only 5% had isolated liver injuries. Additional intra-abdominal injuries seen in 15%. 5 liver related failures. 1 patient became unstable 11 days after injury. No predictors of failure other than development of hemodynamic instability. Nonoperative group had lower incidence of abdominal septic complications, liver related abdominal complications, and transfusion requirements. Patients were not maintained on strict bedrest. Complete healing on CT noted before full activity was approved.
Rutledge R	1995	A statewide, population-based time-series analysis of the increasing frequency of nonoperative management of abdominal solid organ injury. *Ann Surg 222:311-326*	III	Rate of nonoperative management of solid organ injury is increased over time in North Carolina. Trauma centers treat more patients nonoperatively than non-trauma centers. There was increase in how often the more severe injuries were managed nonoperatively.
Allins A	1996	Limited value of routine followup CT scans in nonoperative management of blunt liver and splenic injuries. *Am Surg 62:883-886*		Retrospective review at 2 trauma centers over 2 years. 152 patients, blunt abdominal trauma, isolated hepatic or splenic injury. 30 patients-immediate lap, 122 had CT scan (80%), 64 spleen, 44 liver, 14 both. 99 managed nonoperatively, successful in 94 (95%, 1 patient lap for bile leak, 3 lap for bleeding). 26 had 2nd CT. No 2nd CT showed progression of injury or changed management. 2nd scan obtained at discretion of physician, mean=3.6 days after. Conclude follow-up Ct did not alter therapy.

First Author	Year	Reference Title	Class	Conclusions
Delius RE	1989	A comparison between operative and nonoperative management of blunt injuries to the liver and spleen in adult and pediatric patients. *Surgery 106:788-793*	III	5-year retrospective study of 79 patients; 25 adults treated nonoperatively vs 20 adults treated operatively & 34 pediatric patients treated nonoperatively. Delayed operations were required in 4 adults & 1 child. Transfusions & length of stay were significantly less in nonoperative group. Conclude nonoperative management reasonable alternative in most adults.
Cosentino CM	1990	Transfusion requirements in conservative nonoperative management of blunt splenic and hepatic injuries during childhood. *J Pediatr Surg 25:950-954*	III	6-year retrospective review of 37 blunt liver/spleen injured children. 12 received no blood, 8/11 were isolated injuries. 3 had delayed lap, none for complications related to liver/spleen.
Haller JA Jr	1994	Nonoperative management of solid organ injuries in children. Is it safe? *Ann Surg 219:625-631*	II	3-year prospective study to evaluate nonoperative management of blunt abdominal traumatic injuries in children. All patients with CT documented solid organ injuries were managed by a surgical team. Strict criteria for nonoperative group: hemo-dynamic stability with maximum limit of fluid replacement of 40% blood volume with crystalloid (not blood). Any transfusion or instability led to surgical exploration. 78 children had solid organ injury by CT or laparotomy (28 spleen, 25 liver, 18 kidney, & 7 pancreas). 9/78 initial patients required laparotomy (3 spleen, 2 liver, 1 kidney, 3 pancreas). No deaths or complications in nonoperative group. Low incidence laparotomy (12%) compared favorably with incidence in NPTR (38%).
Coburn MC	1995	Nonoperative management of splenic and hepatic trauma in the multiply injured pediatric and adolescent patient. *Arch Surg 130:332-338*	III	Retrospective 13 year review of 103 cases. 55/83 splenic injuries managed non-operatively, 20/25 hepatic injuries. 6 failures of nonoperative management. Outcome, complications, LOS not statistically significant looking at liver and spleen separately. Conclude nonoperative management among multiply injured did not prove more morbid than operative management.
Bond SJ	1996	Nonoperative management of blunt hepatic and splenic injury in children. *Ann Surg 223:286-289*	III	Retrosp. 6 year review. 179 children with hepatic/splenic injury. Mortality 11%. 156 managed nonoperatively, success rate=97.4%. Delayed intestinal injury in 2 pts.
Keller MS	1996	Associated head injury should not prevent nonoperative management of spleen or liver injury in children. *J Trauma 41:471-475*	III	Retrospective review of Ped. Trauma Registry showed 45 splenic injuries with head injuries, 51 liver + head, 11 spleen + liver + head. 9 (20%) splenic injuries required laparotomy, 5 (10%) liver injured, 4 (36%) liver + spleen. Operative rate was higher with higher ISS. Conclude presence of head injury shouldn't exclude nonoperative management of liver/spleen injuries.
Ruess L	1995	Blunt hepatic and splenic trauma in children: Correlation of a CT injury severity scale with clinical outcome. *Pediatr Radiol 25:321-325*		Prospective study to compare CT grading of hepatic & splenic injuries with outcome measures: requirement for surgical hemostasis, requirement for blood transfusion, and late complications. 97 children (80%) managed nonoperatively without transfusion. Of 69 hepatic injuries, 1 required surgery, 17 transfused. Of 53 splenic injuries, 1 required surgery, 8 transfused. Severity of CT grade did not correspond with need for surgery. Severity of grade correlated with need for transfusion with hepatic, but not splenic injuries.

First Author	Year	Reference Title	Class	Conclusions

Andersson R	1986	Nonoperative treatment of blunt trauma to liver and spleen. *Acta Chir Scand 152:739-741*	III	Retrospective review of 63 pts with blunt hepatic injury, 20 (32%) managed non-op, 13 of 52 splenic injuries managed non-op. Diagnosis by DPL, angio, scintiscan, CT, or US.
Archer LP	1996	Selective nonoperative management of liver and spleen injuries in neurologic-ally impaired adult patients. *Arch Surg 131:309-315*	III	Retrospective case-control study. 87/187 liver/spleen injured managed nonoperatively, 30 (34%) with altered mental status. No complications, no missed injuries. Conclude nonoperative management can be used safely in presence of head injury.
Baron BJ	1993	Nonoperative management of blunt abdominal trauma: The role of sequential diagnostic peritoneal lavage, computed tomography, and angiography. *Ann Emerg Med 22:1556-1562*	III	Retrospective review of 52 blunt abdominal trauma patients. Many excluded, only looked at stable patients undergoing DPL + abd CT. 15 had borderline or (+) DPL & (-) CT. 37 with CT identified injuries, 30 had angio, 17 had embolization. 1 failed embolization & explored. 6 others explored later, 2 with missed injuries, deaths. Conclude DPL useful for screening, CT reserved for documented hemoperitoneum, angio for ongoing blood loss.
Bitseff EL	1984	Splenic trauma: A trial at selective management. *South Med J 77:1286-1290*	III	Retrospective study: 154 patients, 134 with blunt abdominal injuries. 124 patients went to OR <12 hours from admission. Indications: falling hematocrit, hypotension, tachycardia, peritonitis, increasing WBC, polytrauma. Results:114 splenectomies, 10 splenorrhaphies. Complications: 33%, 19 deaths. 30 patients observed >12 hours. 9 nonoperatively, 18 delayed splenectomy, 3 splenorrhaphy. 15 delayed operative patients had complications, no deaths. No follow-up. Nonoperative management should be reserved for stable patients with few associated injuries.
Mucha P Jr	1986	Selective management of blunt splenic trauma. *J Trauma 26:970-979*	III	Retrospective study: 235 patients, 117 splenectomies, 32 splenorrhaphies, 47 non-operatively. Selective criteria: hemodynamic stability, minimal peritoneal signs, maximum transfusion of 2 units. 85% of injuries involved 2 or more systems, average ISS in nonoperative group=24 & operative group=34. Splenorrhaphy was abandoned in 10/42 due to life threatening injuries. Nonoperative patients were followed by CT at 1 or 2 months, & limited activity for 3 months.
Sclafani SJ	1995	Nonoperative salvage of computed tomography-diagnosed splenic injuries: Utilization of angiography for triage and embolization for hemostasis. *J Trauma 39:818-827*	II	Retrospective review of 172 patients with blunt splenic injury treated over 8 year period. 150 patients (87%) with CT diagnosed splenic injury were stable & considered for nonoperative management. 87/90 patients managed by bedrest alone & 56/60 patients treated by angiographic splenic artery occlusion & bedrest had successful outcome. Overall splenic salvage was 88% increasing to 97% in those managed operatively. This included 61 grade III & IV splenic injuries. 60% of patients received no blood transfusions, 3 required delayed splenectomy for infarction or splenic infection. Conclude that hemodynamically stable patients with splenic injury of all grades & no other indication for laparotomy can be managed nonoperatively. Treatment should include arteriography to help select those patients who will be treated successfully by nonoperative protocol. Absence of contrast extravasation on splenic arteriography is a reliable predictor. Coil embolization of proximal splenic artery is an effective method of hemostasis & expands # of patients who can be managed nonoperatively.

First Author	Year	Reference Title	Class	Conclusions

Lawson DE	1995	Splenic trauma: Value of follow-up CT. *Radiology 194:97-100*	III	5 yr. analysis of 108 patients with splenic injury, 44 managed nonoperatively, 2 patients lost to follow-up. 3 groups: I–14:stable pts with 1 CT; II–22:stable with f/u CT; III-6: f/u CT due to symptoms. Double contrast. F/u 1 wk-5yrs. All Gr. I & II had good outcomes. Gr. III – abd pain & dropping HCT, 2 splenectomies, 3 improved, 1 new bleed. Conclusion: if no sx. or change in condition, no need for f/u CT.
Cogbill TH	1989	Nonoperative management of blunt splenic trauma: A multicenter experience. *J Trauma 29:1312-1317*	III	Large experience (6 referral trauma centers) of 832 blunt splenic injuries during a 5-year study period. 112 splenic injuries were managed by observation. 40 patients were <16 years of age or >72 years. Nonoperative management was successful in 39 (98%) children & 60 (83%) adults. Failure was due to ongoing hemorrhage in 12 patients & delayed recognition of pancreatic injury in 1 patient. Of 12 requiring laparotomy for control of hemorrhage, 7 (58%) were successfully treated by splenic salvage surgery. Overall mortality was 3% with 0/4 deaths due to either splenic/associated abdominal injury. Criteria for nonoperative management: 1) Class I, II, or III splenic injury after blunt trauma; 2) no hemodynamic instability after initial fluid resuscitation; 3) no serious associated abdominal organ injury; 4) no extra-abdominal condition which precluded assessment of abdomen. Ultimate splenic preservation using this protocol was 100% in children, 93% in adults.
Williams MD	1990	Trend toward nonoperative management of splenic injuries. *Am J Surg 160:588-592*	III	Retrospective review:143 adult & 26 pediatric patients with splenic injury, most due to blunt mechanisms (91%). Adults had splenectomy & splenorrhaphy more often than children (48% & 30% vs. 31% & 27%), but children had laparotomy without operative treatment of spleen injury & nonoperative management more often (19% & 21% vs. 14% & 8%). Use of operative splenic repair techniques & increased nonoperative management, increased splenic salvage rate during 6 years of study from 41-61% in this mixed group of patients.
Kohn JS	1994	Is computed tomographic grading of splenic injury useful in the nonsurgical management of blunt trauma? *J Trauma 36:385-390*	III	Retrospective review of CT scans of 70 adult & pediatric patients managed nonoperatively for blunt splenic injury. 7 patients (10%) failed therapy & required delayed surgery. CT reviewed by 2 radiologists, blinded to outcome, & graded using 3 published scoring systems. CT grade did not accurately predict success of nonoperative management. High ISS (>15) & age >15 appeared to ID patients at high risk for nonoperative therapy failure.
Wesson DE	1981	Ruptured spleen--when to operate? *J Pediatr Surg 16:324-326*	III	Retrospective review of 5 year experience with splenic injuries. 63 pediatric patients with documented splenic injury by laparotomy, spleen scan, or angiography. 19 (30%) required laparotomy, 44 (70%) managed nonoperatively. Operative intervention undertaken for massive bleeding, associated operative injury, or transfusion > 40cc/kg. Conclude nonoperative management safe in selected cases.
King DR	1981	Selective management of injured spleen. *Surgery 90:677-682*	III	6 year retrospective review of 68 pediatric splenic injuries. 22 had splenectomy (32%), 16 had splenic repair (24%), & 30 (44%) were managed nonoperatively. Change in protocol occurred over that time period where more patients were managed nonoperatively in more recent years. Complication rate was higher in splenectomy group. Conclude that nonoperative management was safe in children.

First Author	**Year**	**Reference Title**	**Class**	**Conclusions**
Kakkasseril JS	1982	Changing treatment of pediatric splenic trauma. *Arch Surg 117:758-759*	III	Retrospective review: 29 pediatric patients with splenic injury. 21 hemodynamically stable patients were diagnosed within 24 hrs by scintigraphy. 14 were admitted to ICU, & mean volume of blood transfused was 700ml. Mean ICU stay=3 days & hospital stay=13 days. Scintigraphy was used to follow patients from 2-16 weeks from day of injury. Of 7 patients requiring surgery, 5 were due to hypotension & 2 due to (+) DPL. Splenectomy was required in 4 patients, 2 partial splenectomies & 1 splenorrhaphy.

Pearl RH	1989	Splenic injury: A 5-year update with improved results and changing criteria for conservative management. *J Pediatr Surg 24:428-431*	III	Retrospective report of current practice (1981-86) of 75 patients treated for splenic injury. 10 operative patients (3 deaths) & 65 nonoperative patients. 45 patients with isolated splenic injury (44 nonoperative & 1 splenorrhaphy), only 5 patients transfused a mean of 11ml/kg of blood. 30 patients with multi-system injury (21 nonoperative & 9 operative), 10 nonoperative patients required mean of 22ml/kg of blood & 9 operative patients required mean of 100ml/kg of blood. Uncomplicated splenic injury LOS was limited to 7 days. Follow-up until complete recovery & limited activities for 2-3 months.
Lynch JM	1993	Is early discharge following isolated splenic injury in the hemodynamically stable child possible? *J Pediatr Surg 28:1403-1407*	III	Retrospective study of 53 children with isolated blunt splenic injuries to determine if ICU monitoring is necessary, can patients be discharged after day 3, and is early discharge policy safe. Conclusion: children can successfully undergo nonoperative management with a very small requirement for transfusion and very few complications.
Velanovich V	1993	Decision analysis in children with blunt splenic trauma: The effects of observation, splenorrhaphy, or splenectomy on quality-adjusted life expectancy. *J Pediatr Surg 28:179-185*	III	Decision analysis paper. Used choice nodes & chance nodes to determine Quality Adjusted Life Expectancy (QALE) for splenectomy vs. NO vs. splenorrhaphy in children. QALE NO – 62.29, Splenor – 62.32, Splenectomy – 61.14. Conclude splenic repair has higher QALE than splenectomy (mostly due to reduction from OPSS)
Morse MA	1994	Selective nonoperative management of pediatric blunt splenic trauma: Risk for missed associated injuries. *J Pediatr Surg 29:23-27*	II	Retrospective review: 120 children with traumatic splenic injuries admitted over 8 years ending in 1990. Specifically looked at 59 patients with associated injuries. No missed injuries & no morbidity or mortality associated with delayed treatment. Conclusions: most children with blunt splenic injury can be successfully treated without surgery, & nonoperative management does not increase the risk of missed associated injuries.
Schwartz MZ	1994	Splenic injury in children after blunt trauma: Blood transfusion requirements and length of hospitalization for laparotomy versus observation. *J Pediatr Surg 29:596-598*	II	Retrospective review: 36 patients <16 years old with blunt injury to spleen. 11/36 were managed nonoperatively. 2 groups were compared & were essentially equal. Conclude that children with splenic injuries from blunt trauma who were stable at time of initial evaluation did not require longer hospitalization or greater volume of transfused blood.
Pranikoff T	1994	Resolution of splenic injury after nonoperative management. *J Pediatr Surg 29:1366-1369*	III	1984-1992. 50 pediatric patients. Initial & 6 wk CT on 25 patients. Complete healing in 44% at 6 wks. Gr. I & II 77% resolved by 6 weeks. Gr. III-V 8% (1/12) resolved by 6 wks. No CT scan changed therapy (restricted activity for 3 mo). All 50 pts. no complications. Conclusion: CT scan may allow earlier return to activity for Gr. I and II patients.

First Author	**Year**	**Reference Title**	**Class**	**Conclusions**
Buntain WL	1988	Predictability of splenic salvage by computed tomography. *J Trauma 28:24-34*	III	Retrospective study: 46 patients initially stabilized in ER & evaluated by abdominal CT scan with splenic trauma classification. Nonoperative management 16 patients (15 class II & 1 class III) & operative 30 patients (4 class I, 9 class II, 16 class III, 1 class IV). No nonop failures, 18 splenorrhaphies, & 12 splenectomies. CT can accurately determine extent of injury & predict need for OR. Early OR affords optimal conditions for splenic salvage.
Benya EC	1995	Splenic injury from blunt abdominal trauma in children: Follow-up evaluation with CT. *Radiology 195:685-688*	III	Retrospective study of follow-up CT in children. 37/99 patients treated nonoperatively received CT (112). Follow-up CT 2 weeks-11 month after injury. Oral IV contrast used. Initial CT retrospectively graded by 2 radiologists. Grades: I-3, II-12, III-11, IV-11. 10 patients had >2 scans. 15/15 Grade I & II healed by 6 months. 6/9 Grade III healed at 4 months. 5/11 Grade IV healed at 5-11 months. No delayed complications. Conclusion: All grade I-II injuries healed by 6 weeks. Healing of more severe lacerations variable.

Lynch JM	1997	Computed tomography grade of splenic injury is predictive of the time required for radiographic healing. *J Pediatr Surg 32:1093-1096*	III	Retrospective. 4 years, 69 patients managed nonoperatively, 58 completed follow-up. Mean age 9.8 years. CT injury identified by discharge US in all cases & then followed by US. Mean time to healing significantly different compared to other groups: I – 3.1 wks., II – 8.2, III – 12.1, IV – 20.7. No long-term complications. Excluded multisystem injured pts. Graded by single radiologist. US performed at 4-6 wk interval until healing occurred. Grade I follow-up done at 1-2 wks. 48 total pts.: I-9, II-26, III-9, IV–4. Conclusion: As injury severity increases, time to healing increases. Most Grade I & II injuries healed by 8 weeks.
Traub AC	1981	Injuries associated with splenic trauma. *J Trauma 21:840-847*	III	5.5 year review of all pediatric splenic injuries, blunt (93%) & penetrating. 80% blunt splenic trauma had associated extra-abdominal injuries. Of blunt trauma patients, 147 had other intra-abdominal injuries. There were 154 major injuries in 87 patients who required operative intervention (incidence 36.5%). For blunt, complication rate 42%. Delayed splenic hemorrhage in 8 pts. Because of delayed hemorrhage & incidence of other operative injuries, conclude that nonoperative management risky, DPL should be used to determine when to operate.
Hebeler RF	1982	The management of splenic injury. *J Trauma 22:492-495*	III	Retrospective study (172 splenectomies, 65 splenorrhaphies, & 32 nonoperatively managed). Post-splenectomy sepsis higher in splenectomy group, but ISS also was higher. Mortality rate from infectious complications lower in splenorrhaphy & nonoperative groups.
Morgenstern L	1983	Nonoperative management of injuries of the spleen in adults. *Surg Gynecol Obstet 157:513-518*	III	Retrospective review: 17 patients treated nonoperatively after diagnosis with scintigraphy and/or arteriography. No delayed operative interventions, <4 units of blood transfused. Mean ICU stay=4 days, hospital stay=10 days. Follow-up every 3 mo. scintiscan for 1 year.
Malangoni MA	1984	Management of injury to the spleen in adults. Results of early operation and observation. *Ann Surg 200:702-705*	III	Retrospective study of 77 adults with splenic injury, 10 patients were observed expectantly. Of 67 patients undergoing laparotomy, 12 spleens were salvaged. Salvage was possible due to limited intra-abdominal injuries, & less blood transfused (3.5 vs. 5.8). 7 of initial 10 patients observed required delayed laparotomy & splenectomy. No immediate associated complications with splenectomy. Length of stay for early operation was 7 days & 10 days for observed patients.

First Author	**Year**	**Reference Title**	**Class**	**Conclusions**
Mahon PA	1985	Nonoperative management of adult splenic injury due to blunt trauma: A warning. *Am J Surg 149:716-721*	III	Retrospective analysis of 11/76 patients with splenic injuries who were initially hemo-dynamically stable, but due to signs of peritoneal irritation, hypotension, or falling hematocrit, 8 required splenectomy. No other characteristics could be determined to predict earlier course of outcome.
Tom WW	1985	A nonoperative approach to the adult ruptured spleen sustained from blunt trauma. *Am Surg 51:367-371*	III	Retrospective study of 53 patients. 34 had immediate splenectomy, 1 failed splenorrhaphy, 19 patients nonoperatively managed (2 delayed splenectomies, 1 not bleeding). Nonop diagnostic tests: liver/spleen scan-24, q-abdominal CT scan-7, angiography-1. Nonoperative management indicated by hemodynamic stability, hemoglobin drop of <2gm/dl, <3 units of blood in 24 hours. Hospital days: 10 days nonoperative management, 14 days operative management. 20 month follow-up utilizing L/S scans & abdominal CT scans, all nonop patients are clinically well.
Johnson H Jr	1986	Splenic injuries in adults: Selective nonoperative management. *South Med J 79:5-8*	III	Early paper of 11 hemodynamically stable patients with isolated splenic trauma managed nonoperatively. 3 patients subsequently required laparotomy 27-43 hours later due to decreasing hemoglobin. 2 underwent splenectomy & 1 had partial splenectomy. Study suffers from lack of CT grading & small number of patients.

Wiebke EA	1987	Nonoperative management of splenic injuries in adults: An alternative in selected patients. *Am Surg 53:547-552*	III	Retrospective study of 10 patients with low velocity injuries managed nonoperatively. All diagnosed with abdominal CT scans & presented to ER hemodynamically stable. 7 successfully managed nonoperatively, 3 required delayed splenectomy for decreasing hematocrit, and/or hypotension. All were clinically well at 18 month follow-up.
Moss JF	1987	Nonoperative management of blunt splenic trauma in the adult: A community hospital's experience. *J Trauma 27:315-318*	III	Retrospective study of 30 patients. 23 treated operatively & 7 nonoperatively. 2 failed, 1 due increased pain, 1 due to pain & decreasing hematocrit. 4 units/patient transfused in operative group & only 1 unit transfused in 2 nonoperative patients.
Nallathambi MN	1988	Nonoperative management versus operation for blunt splenic trauma in adults. *Surg Gynecol Obstet 166:252-258*	III	Retrospective study of 48 patients (20 splenectomies, 18 splenorrhaphies, 10 non-operatively). Nonoperative splenic injuries complicated by delayed operative intervention & splenectomy. Hospital days: 8.7-splenectomy, 7.5-splenorrhaphy, & 16-delayed surgical intervention. Recommend early exploration & repair of spleen to improve salvage rate.
Pimpl W	1989	Incidence of septic and thromboembolic-related deaths after splenectomy in adults. *Br J Surg 76:517-521*	II	Review of >37,000 autopsies over 20 yrs of adults who died after splenectomy compared to matched deceased population of 403 patients who did not have splenectomy. Death-related pneumonia, lethal sepsis with multiple organ failure, purulent pyelonephritis, & pulmonary embolism were all significantly increased in adults who had splenectomy. Conclude: splenectomy has a considerable life-long risk of severe infection & thromboembolism.

First Author	Year	Reference Title	Class	Conclusions
Longo WE	1989	Nonoperative management of adult blunt splenic trauma. Criteria for successful outcome. *Ann Surg 210:626-629*	III	Retrospective study: 252 patients with splenic trauma, 60 treated nonoperatively. 5 pts failed nonoperative therapy. Predictive factors include: localized trauma to left upper quadrant and/or flank; hemodynamic stability; transfusion <4 units blood; <60 years old; & rapid return of gastrointestinal function. Follow-up included abdominal CT scan 5 days & 3 months after injury with activity restriction until complete recovery.
Elmore JR	1989	Selective nonoperative management of blunt splenic trauma in adults. *Arch Surg 124:581-586*	III	Retrospective review: 143 patients with splenic injury, 47 treated nonoperatively, 6 later requiring delayed splenectomy. Diagnostic studies: scintigraphy, CT scan, & DPL. Mean blood transfusion of operative group=4 units, & 1 unit in nonop group. All patients observed in ICU. Splenic salvage rate=78% in isolated trauma group, 29% in poly-trauma group. Follow-up included restricted activity until complete recovery & abdominal CT scan in 6-8 weeks.
Villalba MR	1990	Nonoperative management of the adult ruptured spleen. *Arch Surg 125:836-839*	III	Retrospective review: 51 patients with ruptured spleen; 33 treated nonoperatively, 1 delayed splenectomy & no complications. 14 patients required 3 units of blood. Length of stay for operative group was 7 days for isolated injury & 52 days for polytrauma patient, & 10 days for nonoperative patient. No standard for follow-up.
Pachter HL	1990	Experience with selective operative and nonoperative treatment of splenic injuries in 193 patients. *Ann Surg 211:583-591*	II	Retrospective report of 11-year experience, ending in 1989, of 193 consecutive adult patients with splenic injuries. 76% had blunt trauma. 87% had urgent operation & 66 of these treated by splenorrhaphy or partial splenectomy with splenic salvage. 34% treated by splenectomy alone. 26 additional patients (13.5%) managed without operation. Conclusions: Splenorrhaphy can be safely performed in 65-75% of grade I - III splenic injury. Splenectomy is indicated for more extensive injuries particularly those involving the hilum or resulting in massive parenchymal destruction & should be performed for any patient who is hemodynamically unstable and/or has multiple associated injuries. Nonoperative therapy can be safely accomplished in small group of patients with successful results in 90%. Nonoperative therapy criteria included alert and hemodynamically stable patient with no peritoneal signs & CT documentation of grade I - III splenic injury. Serial CT needed to document healing & to exclude associated injuries.
Koury HI	1991	Non-operative management of blunt splenic trauma: A 10-year experience. *Injury 22:349-352*	III	Retrospective analysis of 10-year period ('78-'88) in community teaching hospital. 23/91 patients with traumatic splenic injuries were treated nonoperatively. Average age=27 years & all but 2 were adults. 21/23 patients (91%) successfully treated nonoperatively. 2 patients (9%) failed nonoperative treatment & required splenectomy. Suggested criteria for nonoperative management in adults: hemodynamic stability, close monitoring, & <4 units of blood transfusion during a 48-hour period.

First Author	Year	Reference Title	Class	Conclusions

Stephen WJ Jr	1991	Nonoperative management of blunt splenic trauma in adults. *Can J Surg 34:27-29*	II	Retrospective review: 17 adult patients with blunt splenic trauma treated by nonoperative protocol. 1 patient failed. 3 complications - 2 pneumonia & 1 pleural effusion atelectasis. No deaths. 5/17 required transfusion & mean length of hospital stay=9.4 days. Compared with similar group of 17 patients who had operation for splenic injuries. Conclude those treated nonoperatively had fewer complications, required less blood, & had similar length of hospital stay. Conclude nonoperative management of selected patients with isolated blunt splenic trauma is safe but note that close monitoring is required.
Feliciano PD	1992	A decision analysis of traumatic splenic injuries. *J Trauma 33:340-348*	III	Review of 72 splenic injuries using decision analysis tree. Assumption made of stable patient with isolated splenic injury. Variable of risk of each arm of tree based on review of literature. First decision branch: observation vs. laparotomy, subtree of chance nodes ending with hospital survival, OPSI death, & transfusion-related death. Sensitivity analysis also done. Conclude observation with 2 fold increase risk transfusion-related deaths. Missed injury possible with use of CT. Question proof of validity of their model.
Jalovec LM	1993	The advantages of early operation with splenorrhaphy versus nonoperative management for the blunt splenic trauma patient. *Am Surg 59:698-705*	III	10-year retrospective study: 185 adult patients with blunt splenic injury at single level I trauma center. Rate of early operation with splenorrhaphy & nonoperative management of blunt splenic patients both increased. Conclusions: Nonoperative management can be successful with low transfusion rate (1.1 units per patient) if patient is completely hemodynamically stable. Patients with multiple injuries or hemodynamic instability should have early operation with splenorrhaphy. Splenic salvage rate=35% with splenorrhaphy and 30% by observation.
Morrell DG	1995	Changing trends in the management of splenic injury. *Am J Surg 170:686-690*	III	Retrospective study of patients admitted during 3 periods from 1965-1994. 207 patients were analyzed. Operation of choice changed from splenectomy to splenorrhaphy & finally observation. Mortality was similar for each period although ISS was higher in last period. Splenectomy patients had higher ISS. Conclude patients treated by splenorrhaphy or observation have increased **[is something missing?]** without adverse outcome.
Godley CD	1996	Nonoperative management of blunt splenic injury in adults: Age over 55 years as a powerful indicator for failure. *J Am Coll Surg 183:133-139*	II	Retrospective analysis: 135 adult patients with blunt splenic injury at single large level I trauma center during 6 years. 11 patients ∃55 years old in which nonoperative management was successful in only 9%. 11 failures in patients ∃55 years contrasted to successful nonoperative management in 66% of younger adults despite similar mean CT splenic injury grading & ISS grading. Complications significantly more prevalent in older patients vs younger patients who failed observation. Conclude age >55 is contraindication to nonoperative management of patients with blunt splenic injury.
Becker CD	1994	Blunt splenic trauma in adults: Can CT findings be used to determine the need for surgery? *AJR AM J Roentgenol 162:343-347*	III	Retrospective analysis of 45 patients with blunt splenic injuries. CT grading & CT-based score derived from extent of parenchymal injury in hemoperitoneum were tested. CT did not reliably determine which patients needed surgery or conservative management. Several high grade injuries were successfully managed conservatively & several grade I or II injuries required delayed surgery. Emphasize clinical findings, rather than CT findings, should be used to determine management strategies.
First Author	**Year**	**Reference Title**	**Class**	**Conclusions**

Sutyak JP	1995	Computed tomography is inaccurate in estimating the severity of adult splenic injury. *J Trauma 39:514-518*	III	Retrospective study: 49 patients with splenic injuries who had preop CT. 31 had initial nonoperative management & 18 went directly to surgery. CT was separately graded by 2 radiologists blinded to clinical results. CT matched OR grading of injury in 10 patients, underestimated it in 18, & overestimated it in 6. Radiologists disagreed on 20% of scans. Caution that management should not be based solely on CT severity since CT poorly predicted operative findings, & interobserver variability was common.
Schurr MJ	1995	Management of blunt splenic trauma: Computed tomographic contrast blush predicts failure of nonoperative management. *J Trauma 39:507-512*	III	Retrospective review of 309 blunt splenic injuries in adults. 89 (29%) initially managed nonoperatively & 12 (13%) failed. Suggest that contrast blush seen on CT splenic angiography is useful predictor of failure.
Cobb LM	1986	Intestinal perforation due to blunt trauma in children in an era of increased nonoperative treatment. *J Trauma 26:461-463*	III	6 years, 12 cases of hollow viscus injury in 600 patients. Jejunum most common. Delays >18 hours in 3 pts. (2 developed peritonitis, 1 – free air). No lab test reliably abnormal. Free air – 5 patients. 2 deaths in patients who presented in extremis. Conclude no lab test reliable. All patients progressed to free air or peritonitis.
Mercer S	1985	Delay in diagnosing gastrointestinal injury after blunt abdominal trauma in children. *Can J Surg 28:138-140*	III	Retrospective study (1974-84): 12 children with hollow viscus injury. Associated injuries common. Jejunal perforation most common. Examined diagnostic factors: 2 stomach perforations–obvious, 2 duodenal perforations–no free air, 7 jejunal–no free air initially (free air seen in 4 at 11-96 hours, 3 had no free air). CT suggestive of injury in 5 (thickening of bowel wall). CT findings diagnostic/suggestive in 88%. Oral & IV contrast essential. Conclude CT findings diagnostic or suggestive in 88%, free air not reliably found.
Brown RA	1992	Gastrointestinal tract perforation in children due to blunt abdominal trauma. *Br J Surg 79:522-524*	III	Retrospective study: 587 pts >13 years old. 29 small intestine rupture (4.9%). 38% had peritonitis on presentation, 19% free air, 22% dilated loop of bowel. 59% all studies non-diagnostic initially. Amylase increased in 31%. Abd CT only used in 2 cases (study took place between 1977-1990). 65% jejunal injury. 41% had progression of x-ray findings. 2 deaths due primarily to CHI. Conclude most patients had non-diagnostic initial studies. Abd CT not used extensively in this study. 41% had progression of x-ray findings.
Talton DS	1995	Major gastroenteric injuries from blunt trauma. *Am Surg 61:69-73*	III	Retrospective study: hollow viscus injuries in 50 pts, 10 years. Abd film–free air in 7 pts. Enema – 1 pt. DPL 14 patients (1 false negative). CT in 14 pts. 9 had free, 5 false (-). Small intestine perforation lowest incidence of associated injury, colon had highest. Small intestine mort 4.5%. 10% injuries missed >24 hours with 60% mortality. Rapid diagnosis had 16% mortality. Conclude CT has high false negative rate, DPL positive in 14/15 pts.

First Author	**Year**	**Reference Title**	**Class**	**Conclusions**
Bensard DD	1996	Small bowel injury in children after blunt abdominal trauma: Is diagnostic delay important? *J Trauma 41:476-483*	III	Retrospective chart review. 168 hemodynamically stable pts over 24 months. 9 pts with hollow viscus injury. 3 had early operation–ID on CT scan, 6 delayed diagnosis (36±16 hrs). 58% injuries ID by CT, 50% of pts with abd wall bruising had hollow viscus injury. Early–4 jejunal perforations. Late–5 small intestine perforations, 1 small intestine stricture. All pts had some abd wall ecchymosis. No change in vital signs in early group, no difference in labs or in PICU stay of hospital days. 8% of solid organ pts in study failed non-op. Conclude vital signs & labs not useful in early diagnosis. Seat belt sign may be useful. CT only identified 58% of injuries.

Ulman I	1996	Gastrointestinal perforations in children: A continuing challenge to nonoperative treatment of blunt abdominal trauma. *J Trauma 41:110-113*	III	Pediatric-retrospective. 1286 admits from 1980-1994. 34 pts with hollow viscus injury. Jejunal–most common. Peritonitis–32/34, free air 6/24, free fluid without solid organ injury–4/13, DPL 8/9. 11 deaths, 2 due to hollow viscus injury. Associated injuries 28/34. DPL's done >6 hours from injury in most. Conclude peritonitis very common, free air much less common. Delayed DPL in suspicious patients useful.
Phillips TF	1983	Perforating injuries of the small bowel from blunt abdominal trauma. *Ann Emerg Med 12:-75-79*	III	9 year retrospective study. 12 patients with hollow viscus injury–9 diagnosed by physical exam or DPL, 3 delayed (2 developed peritonitis within 12 hrs, 1 positive on serial DPL). Septic complications in 50% of pts. Most conscious patients will develop peritonitis within 12 hrs. DPL missed 3 pts Initially. Repeat exam and f/u DPL identified pts. Conclusion: more septic complications than most series. Most conscious patients will develop peritonitis within 12 hrs. Repeated exams essential in suspicious patients.
Donohue JH	1987	Computed tomography in the diagnosis of blunt intestinal and mesenteric injuries. *J Trauma 27:11-17*	III	24 pts treated over 5 years with signs of mesenteric or small intestine injury on abdominal CT scan. 9 pts with mesenteric hematomas were observed with no complications.15 pts were explored, 14 (+). All pts complained of pain, 10/14 guarding. Amylase not reliably done. CT findings in 14 (+) pts: 13 free fluid, 3 free air, 1 extravasation of contrast, 11 bowel wall thickening > 3mm. Conclusion: All pts complained of abdominal pain, free air most common CT finding, but not present in almost 50%. No reliable sign on CT.
Fischer RP	1988	Gastrointestinal disruption: The hazard of nonoperative management in adults with blunt abdominal injury. *J Trauma 28:1445-1449*	III	5-year retrospective review of all blunt abdominal trauma, 6301 adults, 1275 children. 632 abdominal injuries (559 adult, 73 kids). 90% of adults had laparotomy with 87% of injuries requiring operative repair. Laparotomy done on 46/73 children with 45 injuries requiring repair. GI injury occurred in 24.2%; 26.5% in adults, 6.8% in children. GI disruption occurred in 24.5% of adults, 6.5% of children. Conclude that routine non-operative management of adults is not warranted due to high incidence of GI injury.
Sherck JP	1990	Intestinal injuries missed by computed tomography. *J Trauma 30:1-5*	III	Retrospective review of 10 blunt hollow viscus injuries that had initial CT scan. On no CT scan was diagnosis made initially. 2 read (+) on review. Laparotomy occurred 2 hours-3 days after injury. No deaths. Fluid seen in 4 scans. Conclude study of injuries missed on CT. CT can be unreliable in the early diagnosis of hollow viscus injury.

First Author	**Year**	**Reference Title**	**Class**	**Conclusions**
Sherck J	1994	The accuracy of computed tomography in the diagnosis of blunt small-bowel perforation. *Am J Surg 168:670-675*	II	883 pts prospectively followed for outcome or laparotomy. 26 pts with hollow viscus injury: CT suggestive in 24, 12 CT diagnostic (extravasation in 5, FA in 11), 1 false (+). Suggestive findings: free fluid without solid organ injury–10, thickened small intestine–4, small intestine dilatation–3. Results: CT sensitive-92%, specific-94%, (-) predictive value-100%, (+) predictive value-30%. Accuracy 94%. Oral & IV contrast helpful. Conclusion: If definitive & suggestive findings on CT taken collectively, then CT is reasonably accurate, however workup of "suggestive" findings in asymptomatic patients unclear.

Hagiwara A	1995	Early diagnosis of small intestine rupture from blunt abdominal trauma using computed tomography: Significance of the streaky density within the mesentery. *J Trauma 38:630-633*	II	Prospective study of usefulness of "streaky density in mesentery" on CT. 130 pts with CT done within 3 hrs. Sensitivity of sign 69%, specificity 100%. Excluded pts with CT done after 3 hrs. CT not used to decide on operation. 13 SI ruptures: 6/13 free air, 9/13 streaky density, 8/13 intraperitoneal fluid. 112 patients had intra-peritoneal fluid & no injury (specificity 73%). Only 20% of pts with rupture at mesentery had streak. No streak found in pts without SI rupture. Conclude streaky mesenteric density very sensitive on early CT scan. IP fluid without solid organ injury not very useful.
Pasieka JL	1992	Conservative management of splenic injury in infectious mononucleosis. *J Pediatr Surg 27:529-530*	III	Case report of traumatic splenic disruption in 17-year-old boy with mononucleosis. Conservative management was successful. Recommend consideration of splenic preservation in pts with mononucleosis & splenic disruption who are stable & meet other criteria of conservative management.
Purkiss SF	1992	Splenic rupture and infectious mononucleosis: Splenectomy, splenorrhaphy or non operative management? *J R Soc Med 85:458-459*	III	Case report of 4 pts with mononucleosis who had mononucleosis & splenic injury. All had splenectomy & did well. Discuss potential problems of nonoperative management of mononucleosis associated splenic injury. Conclude splenectomy is operative treatment of choice.
Guth AA	1996	Rupture of the pathologic spleen: Is there a role for nonoperative therapy? *J Trauma 41:214-218*	II	Retrospective analysis of 11 patients with abnormal (pathologic) spleen. Nonoperative management was successful in all 11 patients. Mean transfusion requirement was 0.7 units; mean length of stay was 16 days. Conclude pathologic spleen can heal after parenchymal disruption. Criteria for nonoperative management for this subgroup of patients included hemodynamic stability, isolated splenic disruption with AAST grades I through IV, & <2 units blood transfusion with monitoring in critical care setting.
Berman SS	1992	Late fatal hemorrhage in pediatric liver trauma. *J Pediatr Surg 27:1546-1548*	III	Case report of late fatal hemorrhage seen in a child with blunt hepatic injury managed nonoperatively.
Hiraide A	1994	Delayed rupture of the spleen caused by an intrasplenic pseudoaneurysm following blunt trauma: Case report. *J Trauma 36:743*	III	Case report of a single 12-year-old child with isolated blunt splenic injury who developed a pseudoaneurysm requiring emergent laparotomy with splenorrhaphy.