Blunt abdominal trauma: changing patterns in diagnostic and treatment strategies

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Failure rate and complications of angiography and embolization for abdominal and pelvic trauma

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ABSTRACT

Introduction: Angiography and embolization has become the treatment of choice after abdominal trauma or pelvic injury in hemodynamically stable patients with suspicion of internal hemorrhage (contrast extravasation, pseudo-aneurysm or a vessel 'cut-off' diagnosed on CT scan). Some studies, however report a high incidence of rebleeding (failure) or complications. The aim of this study was to evaluate the failure rate and the complications in trauma patients undergoing such procedures.

Methods: All consecutive patients (n=97) admitted to our level-I trauma center between January 2002 and December 2008 in whom angiography with or without embolization was performed were analysed. Complications were classified as organ-specific, puncture-site related and systemic. Additional interventions, required to treat complications were documented.

Results: The overall failure rate was 12%. Overall, 48 complications were documented in 28 patients. Organ-specific complications were observed in 18 patients (19%), especially abscess formation and infarction of the liver. Puncture-site related complications occurred in 3 patients. The incidence of Contrast Induced Nephropathy (CIN) was 24%. Three patients developed renal failure. Nine of the 15 patients with rebleeding could be managed with reembolization or operative packing resulting in an organ salvage rate of 93%. Most (83%) of the organ-specific complications and all of the puncture-site related complications could be managed conservatively or with percutaneous treatment.

Conclusions: In the present study the failure rate and incidence of organ-specific and procedure-related complications were low and often could be managed with nonoperative minimally invasive interventions. Trauma patients undergoing angiography have a high chance (24%) to develop CIN and should therefore receive optimal prophylactic measures to avoid this complication.

INTRODUCTION

Angiography and embolization (AE) has become an accepted therapeutic modality for trauma patients with suspicion of internal hemorrhage. After identification of injuries or bleeding sites on Computed Tomography (CT), an interventional radiologist performs AE and vascular injuries to pelvic vessels as well as solid abdominal organs can be treated in a minimally invasive and nonoperative way.

Since 2002 angiography has become a routine procedure in our trauma center for the evaluation and treatment of selected trauma patients. The interventional radiology department provides 24/7 service for treating patients with suspicion for injuries amenable to angiographic embolization and the angiography suite is equipped to deal with patients undergoing continuous resuscitation.

In our academic Level-1 trauma center, general indications to perform angiography of abdominal vessels include the presence of a contrast extravasation ("contrast extravasation"), a pseudoaneurysm or a vessel 'cut-off' diagnosed on contrast enhanced CT. A large hemoperitoneum in combination with clinical signs of ongoing bleeding is also an indication for angiography. In hemodynamically stable and even unstable patients with high suspicion of the main focus of bleeding in the pelvis, angiography is also considered.

Encouraged by good results of the literature and by its minimally invasive nature indications for performing angiography in trauma patients are expanding and in experienced centers there is a low threshold for performing angiography. However, at the same time, several studies report the high occurrence of rebleeding (failure) or of major complications such as or organ-specific, systemic and puncture-site related complications in comparison with patients who underwent an operative treatment.[1-5] Patients in whom no bleeding is found during the angiogram (negative angiogram) do not benefit from AE, while being exposed to the potential dangers and adverse effects of the procedure.

The aim of this study was to evaluate the failure rate and the frequency and type of AE-related complications in trauma patients undergoing such procedures. Furthermore, the characteristics in patients with a negative angiography are described.

METHODS

All consecutive trauma patients admitted to our level-I trauma center between January 2002 and December 2008 in whom angiography with or without embolization was performed after abdominal trauma or pelvic injuries were identified for review. For data collection we used the trauma registry, the in-hospital financial administrative registration and the prospective interventional radiology registry Complications were identified from the prospectively collected complication database of the department of Surgery. Additionally, a chart review of electronic

and paper hospital registration systems and discharge letters was performed. Patients who were transferred to other hospitals directly after angiography were excluded from the study.
Demographic data included age, gender, trauma mechanism, the Injury Severity Score (ISS) and the presence of a multitrauma (ISS >16). All organ systems for which angiographic evaluation was performed were registered.
Primary outcome was the failure rate (rebleeding) and the frequency and type of complications after angiography with or without subsequent embolization. Failure was defined as clinical and radiological (a contrast extravasation or significant increase of hemoperitoneum on repeat CT-scan) signs of rebleeding requiring operative or radiological (re-) interventions. The definition of a complication as used in our hospital was any unintended and unwanted event or state occurring or following medical care, that is so harmful to the patients' health that it requires (adjustment of) treatment or leads to permanent damage.[6]
Complications were classified as organ-specific, puncture-site related and systemic complications and occurring within 30 days after the last angiography.
Organ-specific complications included ischemia or necrosis of target or non-target organs or tissues and abscess formation. Systemic complications were defined as contrast induced nephropathy (CIN) and renal failure. CIN was defined as an increase in serum Creatinine (Cr) levels of >25% compared to baseline creatinine at 48–72 h after exposure to an iodinated contrast agent compared to baseline serum creatinine levels. Renal failure was defined as loss of renal function requiring (temporary) dialysis.[7] Puncture-site related complications were hematoma of the groin and a false aneurysm.
Additional interventions, required to treat the complications were also documented and included both nonoperative interventions (AE, Percutaneous transhepatic Cholangiography and Drainage (PTCD), Endoscopic Retrograde CholangioPancreatography (ERCP), percutaneous drainage of abscess or infected fluid collections and dialysis) or operative treatment.
Furthermore, the follow-up and frequency and type of complications after negative angiography were described. A negative angiography was defined as an angiography without a subsequent embolization in the same procedure. All continuous variables are presented as medians (with interquartile ranges) and were compared using the Mann-Whitney U test. Categorical variables were calculated as percentages and compared using Chi-square analyses. Statistical significance was declared at the 0.05 level. All statistical analyses were performed using SPSS for Windows, version 15.0.1 (SPSS, Inc., Chicago, IL).

RESULTS

During the study period 97 hemodynamically stable patients underwent angiography procedures for the evaluation of 129 potentially injured organs or pelvic fractures. Table 1 describes

Table 1. Patient characteristics for the total population and the patients in whom a negative angiography was performed

	Total population	Patients with negative angiography
n	97	19
Age *	35 (22-45)	31 (20-59)
Male	71 (73%)	12 (63%)
ISS *	29 (20-36)	27 (23-34)
Potentially injured organs	129	25
Pelvic	47 (36%)	9 (36%)
Liver	31 (24%)	10 (40%)
Spleen	30 (23%)	3 (12%)
Kidney	21 (16%)	3 (12%)
Multitrauma (ISS >16)	84 (87%)	16 (84%)
Trauma mechanism		
Blunt	89 (92%)	18 (95%)
Sharp	8 (8%)	1 (5%)
Admission CT scan	90 (93%)	18 (95%)
Angiography		
Initial	100 (78%)	13 (68%)
Secondary	29 (22%)	6 (32%)
Length of hospital stay *	25 (12-45)	25 (15-45)
ICU stay *	4 (2-12)	7 (2-14)
PRBC < 48 hr *	4 (1-10)	4 (2-6)
FFP < 48 hr *	2 (0-8)	4 (2-6)

* Median (p25-75)
ISS: Injury Severity Score
ICU: intensive Care Unit
PRBC: Packed Red blood Cell transfusion
FFP: Fresh Frozen Plasma

the patient characteristics for the total population and for the patients in whom angiography was negative.

The overall 30-day mortality rate was 8%. None of the patients with a negative angiography died. In addition, no complication-related mortality occurred.

Rebleeding was observed in 15 patients (liver n=5, pelvis n=4, spleen n=3, kidney n=3) for an overall failure rate of 12% (15 of the 120 potentially injured organs) (table 2). The failure rate after AE of the liver, kidney, spleen and pelvis was 16, 14, 10 and 9% respectively. (Re)bleeding occurred in three patients after negative angiography for suspected injury of the kidney, pelvis and liver (failure rate 12%).

Overall, 48 complications were documented in 28 patients after angiography (table 2). The majority of these patients had one complication. In 11 patients more than one complication was observed.

Organ-specific complications were observed in 18 patients, especially abscess formation and infarction of the liver. Puncture-site related complications occurred in 3 patients (two groin hematomas and one false aneurysm of the common femoral artery.
In patients with a negative angiography (n=19), 4 complications occurred in 3 patients. The most frequent complication was Contrast Induced Nephropathy (n=4). No organ-specific, puncture-site related or other systemic complications were encountered. The number and type of complications in trauma patients with (negative) angiographies are described in Table 2.

Table 2. Failure rate and frequency and type of complications in trauma patients with (negative) angiographies

	Total population	Patients with negative angiography
n	97	19
Potentially injured organs	129	25
Failure rate (rebleeding) in follow-up	15 (12%)	3 (12%)
Patients with complications	28 (29%)	3 (16%)
1 complication	17	2
2 complications	6	1
3 complications	2	
4 complications	2	
5 complications	1	
Overall	48	4
Organ-specific		
abscess	8	
false aneurysm splenic artery	1	
liver infarction/ necrosis	4	
gluteal muscle necrosis	1	
urinoma	1	
bile leakage / biloma	3	
other	5	
Overall	23(24%)	
Puncture-site related		
false aneurysm femoral artery	1	
groin hematoma	2	
Overalll	3 (3%)	
Systemic		
contrast induced nephropathy	19	4
renal failure	3	
Overall	22 (23%)	4 (21%)

Contrast Induced Nephropathy (CIN)

In 4 patients the serum creatinin level after angiography or embolization was not measured. CIN occurred in a total of 22 patients (24%). Four of these patients (21%) developed CIN after a negative angiography: two of these patients had no contrast extravasation on CT scan; the indication for angiography was the presence of large hemoperitoneum. Three patients developed

renal failure. In 2 patients temporary dialysis was necessary and one of these patients was hemodialysis dependent at the time of hospital discharge. All these 3 patients underwent an angiography and embolization for suspected hemorrhage from pelvic injury. None of the patients with a negative angiography underwent temporary dialysis or developed renal failure. There were no statistically significant relations (table 3) between the CIN and non-CIN patients in terms of sex (p=0.58), the presence of multitrauma (p 0.49), age (p 0.45) or performing a CT scan (p 0.44). The pre-existing Creatinine was significantly higher in patients with CIN. The incidence of CIN was also increased in patients with AE of multiple organs in comparison with patients with AE of one organ (p 0.08). Although all patients were hemodynamically stable patients with CIN received more PRBC (p 0.02) and FFP (p 0.01) transfusions. The incidence of Diabetes Mellitus, time from injury to AE and amount of contrast medium administered could not be extracted from the retrospective data.

Table 3. Characteristics of patients with CIN and non-CIN

	CIN n= 22	Non-CIN n= 71	P-value
Male female ratio	16:6	52:19	0.58
Multitrauma (ISS>16)	20	62	0.49
Age *	35 (25-55)	35 (20-49)	0.45
Age > 55 year	16	59	0.36
Performing CT scan	20	67	0.44
AE multiple organs	9	16	0.08
Number of PRBC *	7 (2-26)	4 (0-6)	0.02
Number of FFP *	7 (0-21)	2 (0-5)	0.01
Pre-existing Creatinine *	87 (85-98)	77 (60-95)	0.04

* Median (p25-75)
PRBC: Packed Red blood Cell transfusion
FFP: Fresh Frozen Plasma

Treatment of rebleeding and complications

All 9 patients with failure of AE or negative angiography after liver and pelvic injury could be managed with reembolization or surgery without resection leading to salvage of the target organ All patients with renal and splenic injuries who failed AE or negative angiography (n=1) underwent splenectomy or nephrectomy. The overall organ salvage rate was 93%.

Most (83%) of the organ-specific complications could be managed with minimal invasive interventions such as embolization, PTC, ERCP or percutaneous drainage. All abscesses were treated by percutaneous drainage. Four patients (17%) underwent operative treatment to solve the complication (Table 3). The two patients with a local hematoma in the groin were treated conservatively. The patient who developed a false aneurysm was treated with percutaneous thrombin injection. Table 4 shows the results of the treatment of rebleeding and complications after (negative) angiography.

Table 4. Treatment of rebleeding and complications in patients treated with angiography

	N	Treatment
Rebleeding	15	AE n= 5 splenectomy n= 3 nefrectomy n= 3 packing n= 4
Organ-specific complications		
abscess organ/ (retro)-peritoneal	8	percutaneous drainage
false aneurysm splenic artery	1	angiography and embolization
liver infarction/ necrosis	4	hemihepatectomy n=1 cholecystectomy n= 1 conservative n=2
gluteal muscle necrosis	1	necrotectomy
urinoma	1	percutaneous drainage
bile leakage / biloma	3	PTC n= 1, ERCP n=1, percutaneous drainage n=1
other	5	conservative n=4 operative n=1
Puncture-site related		
false aneurysm femoral artery	1	percutaneous trombin injection
groin hematoma	2	conservative
Systemic		
contrast induced nefropathy	19	CVVH n=2
renal failure	3	dialysis n=1

PTC: Percutaneous Transluminal Cholangiography
ERCP: Endoscopic retrograde cholangiopancreatography
CVVH: continuous veno- venous hemofiltration

DISCUSSION

The primary aim of this study was to describe the failure rate and frequency, type and consequences of complications in trauma patients after AE for internal haemorrhage. In the present study 97 patients underwent an angiography for the evaluation of 129 potentially injured organs.

The most frequent complication in this study was CIN with an incidence of 23%. The literature reveals that the incidence of CIN in patients with normal renal function has been calculated to be less than 2%.[8] However, it can be considerably higher (50–90%) in those with risk factors (elderly >55 year, severe renal insufficiency at baseline and Diabetes Mellitus).[9,10] Recent literature describes an incidence of 5,1% of CIN in trauma patients who received a contrast enhanced CT scan.[5]

There was no significant difference in gender, the presence of multitrauma and age >55 year between CIN and non-CIN patients. Diabetes Mellitus and the time from injury to AE could possibly contribute to the incidence of CIN among patients. However, these parameters could not be extracted due to the retrospective design of the study.

An explanation for the difference in incidence between this study and our results could be the total administered dose of contrast agent, i.v for CT and i.a for subsequent AE. A recent meta-analysis showed a close relationship between the dose of iodine per ml of GFR, and the occurrence of CIN.[11] Almost all our patients underwent both a contrast enhanced CT scan and AE. Furthermore, the incidence of CIN was more likely increased in patients in whom AE of more than one organ was performed, which is probably also related to the increase in contrast agent in these procedures. However, the exact amount of contrast medium administered to patients during AE was not registered.

In trauma patients the presence of hypotension due to shock and multi-organ damage as well as volume depletion in trauma patients are also risk factors for CIN. Therefore it is not certain that the renal impairment could be attributed to CIN, but in this complex group of patients, there may be many factors contributing to renal impairment.

The acute indications of CT scanning and performing an AE in trauma patients make implementation of preventive protocols before imaging difficult. Despite numerous clinical trials and meta-analyses, the utility of the often-used antioxidant N-acetylcysteine and/or sodium bicarbonate infusion in CIN prophylaxis remains unclear, not least because the statistical design of many of the relevant studies has been criticized.[12-15]

Current best practice calls for intravenous periprocedural volume expansion with normal saline at 1 ml/kg body weight for at least 6 hours before and after the procedure, but this is often not practical in trauma patients.[16] Although bolus volume expansion during the procedure has been reported to be inferior to intravenous volume expansion, this method should be strongly considered for all trauma patients who underwent CT scanning and AE, especially in patients with other risk factors for CIN.

Furthermore, whole body CT and AE protocols that incorporate the lowest contrast medium volume and iodine dose to achieve a diagnostic and therapeutic result in combination with the use of iso-osmolar contrast agents should be used to prevent CIN.

The present study showed rebleeding in 15 patients (failure rate 12%). This failure rate is ccomparable with the literature.[17-22] Delayed rupture of organs/vessels could explain rebleeding and is of major concern because this type of complication remains difficult to predict. Historically, most patients with rebleeding were treated surgically. Currently, a second attempt of AE can be considered, which further can increase the nonoperative target organ salvage rate. In the present study 5 patients were treated with a second AE.

Most of the organ specific complications could be managed with minimal invasive interventions such as embolization, PTC, ERCP or percutaneous drainage to solve the complications. This study showed a low incidence (3%) of puncture-site related complications. In addition, these complications could be managed nonoperatively.

Recent literature suggests that with the increased use of AE, an increase of major complications such as rebleeding, organ-specific, systemic and puncture-site related complications occurs.[1-5] However, these results must be interpreted with some caution, because they are based on

cohort studies, which were compared with results of historical studies. Prospective randomized controlled trials comparing operative treatment and AE have never been published. Furthermore, the question is whether the complications, especially biliary complications have arisen from the accident itself or were secondary to the treatment with AE.[23] Four of the 19 patients (21%) with a negative angiography developed a total of 4 complications. The incidence of CIN in this particular patient group was 21%. Contrast-enhanced CT scanning can help to select both hemodynamically stable patients or fluid responders for angiography and embolization but the optimal patient selection still remain to be established. In this retrospective study the specific indication for angiography could not always be extracted. Further prospective studies should therefore focus on proper patient selection and the prevention of procedure related complications.[24]

In our hospital the indication for AE has altered after the results of this study. Hemodynamically patients without contrast extravasation on CT scan are initially treated with observation. In case of failure AE can still be pereformed.

This study has several limitations, which are mainly related to the retrospective analysis of data. Although the complications were prospectively registered, there may be missing data. Furhermore, a Type 2 error could be present, due to the low patient numbers for complications. As stated before, the specific considerations that have led to angiography could not always be assessed. The definition of CIN used in this study is the same that is used in the general literature to define CIN after percutaneous vascular interventions. However, in the literature there are multiple definitions for CIN making it difficult to compare these results to other studies. Another limitation is the relatively small number of patients with (negative) angiography in our series making it difficult to draw strong conclusions. The rate of negative angiographies however is comparable to other Level 1 trauma centers.[1]

CONCLUSION

In this present study the failure rate and incidence of organ-specific and procedure-related complications after AE were low and comparable with the literature. In the vast majority, complications often (83%) could be managed with nonoperative minimal invasive interventions. However, a high incidence (23%) of CIN in trauma patients both after AE as well as after (negative) angiography was observed. Trauma patients undergoing angiographic treatment have shown to have a high chance for developing CIN and should therefore receive optimal prophylactic measures to avoid this complication. Further strategies to prevent CIN should focus on further optimization of patient selection avoiding negative angiograms and the use of whole-body CT protocols with the use of low iodine dose and volume of intravenous contrast medium.

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