Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.elsevier.com/locate/jcot

Original Article

Predictive parameters for angiography and embolization in the bleeding pelvic fracture

V. Anandakumar MMed (Ortho)^{a,*}, Fareed K. Hussein FRCS (Ortho)^b,
B. Varuun MS (Ortho)^{a,b}, R. Zhu MBBS^{a,b}

^a Changi General Hospital, 2 Simei Street 3, Singapore 529889, Singapore

^b National University Hospital, 5 Lower Kent Ridge Road, Singapore 119074, Singapore

ARTICLE INFO

Article history:

Received 24 July 2012

Accepted 16 January 2013

Available online 22 January 2013

Keywords:

Pelvic fracture

Angiogram

Embolization

ABSTRACT

Aim: In the bleeding pelvic fracture, decision needs to be made on definitive control of bleeding whilst resuscitation. The decision for angiography in unstable patients is difficult and this study hopes to identify the parameters that may aid in this decision.

Methods: 121 patients with traumatic pelvic fractures were identified from June 2005 till June 2010, from the National University Hospital, Singapore. Out of these 121 patients, 15 patients who underwent angiographic evaluation were identified. 11 out of the 15 had angiography and embolization done, while the remaining 4 only had angiography done. Another group of 29 patients who had not undergone angiography were identified from the main population via age-matched criteria. Clinical parameters were compared between the 15 angiography patients and the 29 non-angiography group of patients.

Results: Angiography group had a larger proportion (80%) with contrast blush noted on contrast-enhanced CT scan (CECT), a higher proportion with unstable pelvic fracture patterns as classified by Tile (80%), and Young and Burgess (92.4%) ($p < 0.05$). Embolized group had higher proportion (81.8%) with hematoma and with blush on CECT (100%), and higher proportion with unstable fracture patterns (UFPs) (72.7%) as classified by Tile ($p < 0.05$). Positive predictive value for embolization using hematoma alone is 39% while that of blush alone is 73% and unstable Tile fracture alone is 47%. Positive predictive value of combined hematoma, blush and unstable Tile fracture pattern is 75%.

Conclusion: Significant predictive factors for angiogram would be unstable pelvic fracture patterns, presence of hematoma and contrast blushing on CT.

Copyright © 2013, Delhi Orthopaedic Association. All rights reserved.

1. Introduction

High-energy pelvic fractures are life-threatening injuries. Extensive bleeding associated with these fractures is common. 15%–30% of patients with high-energy pelvic injuries are hemodynamically unstable which may be directly related to

blood loss from the pelvic injury. Hemorrhage remains the leading cause of death in patients with these fractures with an overall mortality rate between 6 and 35%.

Bleeding associated with pelvic fractures requires efficient evaluation and timely intervention. One of the most important decisions in a bleeding pelvic fracture is the decision

* Corresponding author. Tel.: +65 97934000, +65 68503571.

E-mail address: rapslider@yahoo.com (V. Anandakumar).

0976-5662/\$ – see front matter Copyright © 2013, Delhi Orthopaedic Association. All rights reserved.

<http://dx.doi.org/10.1016/j.jcot.2013.01.005>

whether to proceed to the interventional suite for pelvic arterial angiogram and embolization. In Singapore hospitals, immediate recognition of instability caused by pelvic trauma is typically followed with resuscitation via ATLS (Advanced Trauma Life Support) principles followed by use of blood products, external mechanical stabilization devices, followed by decision for intervention. Emergency intervention for the pelvis, besides external fixation can be in the form of angioembolization or laparotomy with extraperitoneal packing.

We carried out a Level III retrospective observational single-institution study at the National University Hospital, Singapore on a patient population of 121 traumatic pelvic fractures over a period of 5 years from June 2005 to June 2010.

The purpose of our retrospective study was to answer the clinical question as to what were the significant clinical commonalities that were present in these patients with the bleeding pelvic fracture who underwent angiography and embolization.

2. Study design, methodology and results

2.1. Design and methods

121 patients with a traumatic pelvic injury sustained from a significant injury i.e. fall from height, road traffic accident were identified from June 2005 till June 2010 from a tertiary trauma centre in Singapore, The National University Hospital trauma registry. Low energy falls with osteoporotic pelvic fractures were excluded from the study. Emergency department mortalities were excluded from the study (Died on arrival to the ED).

15 patients who underwent angiography 11 with and 4 without embolization were identified from these 121 patients and the characteristics of this particular patient population were evaluated based on several parameters such as 1. Systolic blood pressure (SBP) on arrival 2. Base Excess 3. 24-hr fluid and blood requirements 4. CECT (contrast enhanced CT) findings 5. ISS (Injury Severity Scores) 6. Fracture types based on classification. 7. Hemoglobin (Hb) pre and post angiography 8. Coagulation profiles 9. Presence of long bone fractures 10. Presence of general surgical injuries.

Another 29 patients from the main group were age-matched and analyzed. These 29 patients had not undergone angiography. They were also evaluated via 2-sample t-test with the remaining 106(121–15) by the parameters stated above and were found representative of the main patient group of 121 patients.

Case notes and computer records of patients were traced.

The angiography group and the non-angiography group were age-stratified and analyzed based on the parameters studied. There were 15 patients in the angiogram group (inclusive of the patients embolized) and 29 in the non-angiogram group.

A further sub-analysis was done between the patients who underwent embolization and those that did not have embolization (inclusive of angiography without embolization). Amongst the total number 44 patients analyzed, 11 had undergone embolization and 33 had not.

The results of the study were analyzed using the SPSS program version 17.0.

3. Results

Among the parameters analyzed between the 2 groups, it was noted that across the age groups, there were a few significant differences.

The mean 1st hemoglobin levels (Hb1), which is the 1st laboratory result that was obtained from the patient on presentation in the Emergency department, was significantly lower in the angiography group (mean = 11.13) compared to the non-angiography group (mean = 13.12). It was also noted that the angiography-group had a lower mean 2nd hemoglobin (Hb2) (mean = 9.28), which is the hemoglobin levels obtained after angiography was performed either with or without embolization ($p < 0.05$). It is interesting to note that the mean Hb post angiography was lower compared to the Hb pre angiography (Fig. 1).

The author believes that the reason for this could be continued bleeding from the other sources i.e. venous and bone bleeding. Another possibility could be the blood loss that had already occurred in the intervening period before angiogram and/or embolization was done to stop any bleeding (Fig. 2).

The angiography-group had a significantly larger group (12 out of 15) (80%) with blush of contrast noted on contrast enhanced CT scans as compared to the non-angiography group (11 out of 29) (10.3%) and this was statistically significant ($p < 0.05$) (Table 1).

The angiography-group had a higher proportion of patients with an unstable pelvic fracture as classified by Tile (80%) (12 out of 15) and Young and Burgess (80%) (12 out of 15), and this was statistically significant in this study when compared to the non-angiography group of whom the unstable pelvic fracture by Tile's classification was 17.2% (5 out of 29) and by Young's and Burgess 48.4% (14 out of 29) ($p < 0.05$). (Unstable Tile fractures were B and C types and Young and Burgess unstable fractures were APC II, APC III, LC II, LC III, VS and CM fracture patterns).

Fig. 1 – Graphical representation of the significant differences that the angiogram group shares in common.

Fig. 2 – Box plot of Hb. Hb1 represents initial Hb on presentation in the Emergency Department and Hb2 is the Hb post procedure. Differences (Hb1–Hb2) are not significant between angiography and non-angiography group.

Lower mean SBP levels, lower base excess, higher fluid requirements, higher ISS scores and a higher proportion of associated general surgical injuries and decreased long bone fracture incidence were noted in angiography group. However, these differences were not statistically significant in this study.

Further analysis was done between the patients embolized in the angiography group, compared to those that were not. The comparison therefore is between the 11 that required embolization and the 33 that did not require embolization.

Of the 11 embolized 9 showed hematoma on the CECT scan (81.8%) as compared to the non-embolized group (14 out of 33) (42.4%) ($p < 0.05$). Of the 11 embolized, all 11 had blush on CECT as compared to 4 out of the 33 in the non-embolized group ($p < 0.05$). 72.7% of the fracture patterns in the embolization group were unstable as classified by Tile, compared with the 27.3% in the non-embolized group ($p < 0.05$).

The rest of the clinical parameters tested were not statistically significant in this study.

Positive predictive value for embolization using hematoma alone is 39% (9 out of 23) while that of blush alone is 73% (11 out of 15) and unstable Tile fracture pattern alone is 47% (8 out

of 17). Positive predictive value of combined hematoma, blush and unstable Tile fracture pattern is 75% (9 out of 12). Out of 12 patients with presence of hematoma, blush and an unstable fracture pattern, 9 of these patients underwent an embolization as they were noted to have an actively bleeding vessel on angiogram.

4. Discussion

4.1. Angiography and embolization

Arterial embolization is a rapid and effective technique for controlling pelvic fracture hemorrhage. In our institution, there is always a radiologist on duty who is qualified in diagnostic and therapeutic angiography. Moreover angiography is done in the operating theatre, which is ideal. There is an anaesthetist on standby in the event that patient may deteriorate and there is a necessity for laparotomy.

Agolini et al¹ in his 1997 study made a few observations related to the success of embolization. In his study, he noted that the effectiveness of the angiography was closely tied to the experience of the radiologist, the time it took for angiography to be performed from the time of the injury and ease of transfer of the patient to the angiography suite.

Velmahos et al 2002² further confirmed that where facilities exist for angiography, it should be offered early and liberally. His earlier study in 2000³ highlighted the safety and efficacy of angiography and that it can be used as a first-line measure in controlling pelvic bleeding. Furthermore, the advantages of angiography are the possibility that if offered early, bleeding could be controlled by a less aggressive means as compared to intervention through laparotomy.

Jen et al 2011⁴ confirmed this together with Eastridge et al 2002⁵ when increased mortality rates were reported when patients with hemorrhagic shock associated with an unstable pelvic fracture and hemoperitoneum underwent laparotomy before angioembolisation for the pelvic fracture. Angiography and subsequent transarterial embolization (TAE) made it possible to treat multiple active bleeders simultaneously and to avoid further trauma of laparotomy in some cases.

Control of the arterial hemorrhage before laparotomy also prevents the aggravation of retroperitoneal bleeding due to reduction of the tamponade effect by laparotomy.

Huttinen et al⁶ observed that in 85% of pelvic fracture (23 out of 27 autopsy examinations), bleeding was noted to be from the small arteries at the fracture site.

Verbeek et al⁷ and Heetveld et al⁸ emphasized on the management of traumatic bleeding pelvic fractures according to guidelines and a decision-making tree. They noted that hemorrhage related mortality was high in the group that underwent laparotomy and the high negative laparotomy rates were to a significant extent due to lack of guidelines governing management. They found that timely angioembolization and orthopaedic intervention was important for hemorrhage control. Persistent bleeding requires decision making within 90 min as to whether patient should proceed to laparotomy and pelvic packing or angioembolization. Heetveld et al also recommended early non-invasive stabilization of the pelvis (C-clamp and binder) followed by

Table 1 – Significant categorical variable differences between the angio vs. the non-angio group.

	Angiogram	No angiogram	P value (chi sq)
Tile unstable	12	5	<0.05 (0.0005)
Tile stable	3	24	
Young unstable	12	14	<0.05 (0.007)
Young stable	3	15	
Hematoma	12	11	<0.05 (0.0008)
No hematoma	3	18	
Blush	12	3	<0.05 (0.0005)
No blush	3	26	
GS injury	6	7	>0.05
No GS injury	9	22	
LB fracture	1	7	>0.05
No LB fracture	14	22	

GS = General surgical and LB = Long bone.

angiography within 90 min if no intraabdominal bleeding is discovered.

From the literature it is clear that when patients are stable, early angiography can prevent more morbidity and provide a means of stopping arterial bleeding by means of embolization.

In our study, although we noted a significant lower Hb among the angiography group, these levels were not alarmingly low (mean = 11.13).

The authors feel that the reason for this could be the fact that these patients were brought in before more blood loss could ensue. This is possible in a small country like Singapore whereby patients can be brought to a nearby hospital within half an hour from any site of trauma in the island-city.

Moreover this is one reason why resuscitation is successful in many of these patients, allowing them to undergo diagnostic procedures like CT scans which leads us to better appreciate the pathology and institute appropriate treatment. The presence of hematoma and contrast blushing seen in CT scans significantly makes a difference in the decision for embolization in our study.

Jeroukhimov et al⁹ observed that high pelvic AIS, low base excess and increased transfusion requirements were predictive for early angiography. These were indicators of arterial bleeding and in this group of patients; recommendations for liberal and early angiography were made.

In our study, a lower Hb level was a significant predictor as to whether a patient underwent angiography or not. Ours however is a retrospective study and more prospective data is required to determine the Hb levels that would be significant to herald the need for angiography. Nevertheless ours is the 1st study of this type to find Hb as a significant predictor for choosing the angiographic limb of treatment.

The C-clamp and adjunctive embolization also appear to be as efficient in controlling hemorrhage as the C-clamp associated with laparotomy and pelvic packing as observed by Sadri et al.¹⁰ In those hospitals where angiography facilities are available, it seems reasonable to recommend that patients who remain hemodynamically unstable after rapid application of the C-clamp be treated with arterial embolization as opposed to performing a laparotomy and pelvic packing with its increased risk of mortality and morbidity. Although the C-clamp was effective in controlling hemorrhage in the majority of patients in this review, 36% required arterial embolization to control hemorrhage.

Miller et al¹¹ claims active pelvic bleeding in 73% of hypotensive non-responders, suggesting that the proportion of arterial injuries is quite high and this is also noted in Huttinen's autopsy studies that share the same observation.

In our hospitals placing a C-clamp is not routine in the ED. A pelvic binder is commonly used as an initial measure to close the pelvis and to reduce pelvic volume and increase tamponade. Any further intervention in terms of placement of an external fixator or C-clamp is usually done in the operating theatre concurrently with any general surgical procedure or as a stand-alone emergency orthopaedic procedure to achieve stability in the hope of maintaining hemodynamic stability.

The opponents to early angiography mainly cite the time element as the major downside to early angiography. It is thought to be time consuming and some studies have claimed

10 h between admission and angiography.¹² Moreover, the availability of an in-house radiologist and the ability to resuscitate patients in the angiography suite if they deteriorate are some of the concerns cited. Some of these concerns and fears lead trauma teams to discount primary angiography as a feasible and perhaps even the most important step in the management of the bleeding pelvic fracture. The arguments against implementation of the arteriographic treatment limb are often logistic and surmountable.¹³

When angiography is used as the main modality of treatment, patient selection is most important, together with the knowledge that angiography may need exploration of intra-abdominal vessels and hepatic and splenic bleeding can be treated with selective embolization.¹⁴

5. Pelvic fracture patterns

In the treatment of patients with pelvic fractures, surgeons should evaluate fracture stability and injury severity immediately after admission to predict the prognosis and establish the initial treatment plan.

Miller et al noted that fracture patterns of APCII, III, LCII, III, VS and CM are more likely to have arterial bleeding, as well as fractures through the sciatic notch (due to proximity of the superior gluteal artery).

Eastridge further confirmed this at al when SFPs (LC I, APC I) and UFPs (APC II, III, LC II, III, VS and CM) were compared, SFPs being stable fracture patterns and UFPs being unstable fracture patterns.

His study suggests that once patient is in shock and is undergoing resuscitation, pelvic fracture patterns determine the next step in management or rather are useful in determining treatment. In SFPs, intraperitoneal bleeding seems to be the most substantial factor giving rise to shock, which would probably require laparotomy and its important to have this at the back of the mind even in the case of a negative FAST study. In UFPs, shock was mostly from the pelvic source, and if still persistent despite binder techniques and resuscitation, angiogram is probably the best way forward.

Our study did show significance in correlation of Tiles and Young and Burgess Classification of stability of fracture patterns when comparing the angiography and non-angiography groups.

The angiography group had a higher proportion of patients with an unstable pelvic fracture as classified by Tile (80%) and Young and Burgess (80%), and this was statistically significant in this study when compared to the non-angiography group of whom the unstable pelvic fracture by Tile's classification was 17.2% and by Young's and Burgess 48.4% ($p < 0.05$).

Furthermore, when comparing embolization vs. non-embolization 72.7% of the fracture patterns in the embolization group were unstable as classified by Tile, compared with the 27.3% in the non-embolized group ($p < 0.05$).

6. Summary and conclusion

This retrospective study aimed to identify clinical parameters that were statistically significant amongst patients who went for angiography as compared to those who did not.

The aim is to provide a guide to clinicians to decide on which patients should be chosen for angiography.

It is noteworthy that the prerequisite for patients undergoing angiogram is that they should be stable enough hemodynamically to undergo the procedure. In those circumstances, early angiogram has shown to be beneficial in these patients.

Other sources of bleeding should be arrested as well with the aid of provisional pelvic binders and external fixation. Nevertheless, low Hb, an unstable pelvic fracture pattern, presence of hematoma and blushing on CECT are factors that would alert a clinician to the presence of arterial bleeding and emergent angiogram will be beneficial.

The author hopes that a prospective study can be carried out to support the findings of this paper.

Conflicts of interest

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

REFERENCES

1. Agolini SF, Shah K, Jaffe J, et al. Arterial Embolization is a rapid and effective technique for controlling pelvic fracture hemorrhage. *J Trauma Inj Infect Crit Care Sept.* 1997;395–399.
2. Velmahos GC, Toutouzas KG, Vassiliu P, et al. A prospective study on the safety and efficacy of angiographic embolization for pelvic and visceral injuries. *J Trauma.* 2002;52:303–308.
3. Velmahos GC, Chahwan S, Falabella A, et al. Angiographic embolization for intraperitoneal and retroperitoneal injuries. *World J Surg.* 2000;539–545.
4. Fang JF, Shih LY, Wong YC, et al. Angioembolization and laparotomy for patients with concomitant pelvic arterial hemorrhage and blunt abdominal trauma. *Langenbecks Arch Surg.* 2011;396:243–250.
5. Eastridge BJ, Starr A, Minei JP, et al. The importance of fracture pattern in guiding therapeutic decision-making in patients with hemorrhagic shock and pelvic ring disruptions. *J Trauma.* 2002;53:446–451.
6. Huttinen VM, Slatis P. Postmortem angiography and dissection of the hypogastric artery in pelvic fractures. *Surgery.* 1973;454–462.
7. Verbeek D, Sugrue M, Balogh Z, et al. Acute management of hemodynamically unstable pelvic trauma patients: time for a change? Multicenter review of recent practice. *World J Surg.* 2008;32:1874–1882.
8. Heetveld MJ, Harris I, Schlaphoff G, et al. Hemodynamically unstable pelvic fractures: recent care and new guidelines. *World J Surg.* 2004;28:904–909.
9. Jeroukhimov I, Ashkenazi I, Kessel B, et al. Selection of patients with severe pelvic fracture for early angiography remains controversial. *Scand J Trauma Resuscitation Emerg Med.* 2009.
10. Sadri H, Ngyuen-Tang T, Stern R, et al. Control of severe hemorrhage using C-clamp and arterial embolization in hemodynamically unstable patients with pelvic ring disruption. *Arch Orthop Trauma Surg.* 2005;125:443–447.
11. Miller PR, Moore PS, Mansell E, et al. External fixation or arteriogram in bleeding pelvic fracture: initial therapy guided by markers of arterial hemorrhage. *J Trauma.* 2003;54:437–443.
12. Gansslen A, Giannoudis P, Pape HC. Hemorrhage in pelvic fracture. Who needs angiography? *Curr Opinion Crit Care.* 2003;9:515–523.
13. Gyling SF, Ward RE, Holcroft JW, et al. Immediate external fixation of unstable pelvic fractures. *Am J Surg.* 1985.
14. Ben-Menachem Y, Coldwell DM, Young JW, Burgess AR. Hemorrhage associated with pelvic fractures: causes, diagnoses, and emergent management AJR. *Am J Roentgenol.* 1991.