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ORIGINAL ARTICLE

External fixation in pelvic fractures

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Abstract Pelvic fractures account for 4–5% of all fracturated patients, and they occur in 4–5% of politraumatized patients. In the most of the cases, they are consequent to high-energy trauma with a high percentage of lesions of other organs (cerebral, thoracic, and abdominal lesions. The most of the patients (80%) who die are dying within the first hours after trauma for a massive hemorrhagic shock. When the pelvic fracture and the patient's hemodynamic conditions are both unstable, osteosynthesis of the fracture is mandatory. Fracture stabilization should be performed within the first hour after trauma (as soon as possible), and it should be considered as part of the resuscitation procedure. We usually make an urgent stabilization of pelvic fracture with an anterior external fixator technique. We have revised all unstable pelvic fractures treated in our department (Orthopaedic Clinic Pisa University) from 2000 up to the 2005 to determine a correct treatment protocol for these lesions. Pelvic stabilization, reducing the pelvic volume and bleeding from the stumps of fracture, determines the arrest of the hemorrhage, as evidenced by the sharp decline in the number of transfusions in postoperative period. In these cases, there is an absolute indication for an urgent pelvic stabilization. Pelvic stabilization, whether temporary or permanent, allows to control the bleeding because it (1) leads to a reduction in the volume pelvis with a containment on the retro-peritoneal hematoma (2) reduces bleeding from the fracture fragments (3) reduces motility fracture promoting the blood clotting. The stabilization of the pelvis also makes it easier to manage the patient and his mobilization for the implementation of subsequent investigations. In our experience, external fixator accounts for its characteristics the gold standard approach for the urgent stabilization of these lesions, and, for most of them, it can be used as the definitive treatment. External fixation is a quick and easy procedure for pelvic fractures stabilization for surgeons with experience with this technique.

Keywords Pelvic fracture · Hemorrhage · External fixation · Trauma · Pelvic ring

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Introduction

Pelvic fractures account for 4–5% of all fracturated patients [1], and they occur in 4–5% of politraumatized patients [2]. In the most of the cases, they are consequent to high-energy trauma with a high percentage of lesions of other organs (cerebral, thoracic, and abdominal lesions) [3]. These lesions may influence the patient outcome. Mortality associated with pelvic fractures ranged from 5 to 42%. Pelvic fractures represent the third most common cause of death in trauma [4–6]. The most of the patients (80%) who die are dying within the first hours after trauma for a massive hemorrhagic shock [6–12].

When the pelvic fracture and the patient's hemodynamic conditions are both unstable, osteosynthesis of the fracture is mandatory [13, 14]. Fracture stabilization should be performed within the first hour after trauma (as soon as possible), and it should be considered as part of the resuscitation procedure [15, 16].

We usually make an urgent stabilization of pelvic fracture with an anterior external fixator technique.

We have revised all unstable pelvic fractures treated in our department (Orthopaedic Clinic Pisa University) from 2000 up to the 2005 to determine a correct treatment protocol for these lesions.

Materials and methods

In 5 years (2000–2005), 47 patients with unstable pelvic fractures have been treated at our department. We reviewed 41 of them (21 males and 20 females) with an average age of 37.7 years old. Almost all injuries were caused by high-energy impact forces (road traffic accidents in 34 cases, 2 falls from high, 2 falls out of the widow, 1 work accident, 1 agricultural accident and 1 crush trauma). All patients had a multiple injuries such as lower limb fractures. We observed 3 bladder injuries, 2 perineal and sigma injuries, 1 vaginal injury, 2 spleen injuries, 1 diaphragmatic Herniation, 2 nerve injuries (sciatic nerve and brachial plexus) and 2 artery lesions (mesenteric artery and inferior gluteal artery).

In the emergency room, we make an accurate clinical evaluation of the pelvis. Orthopedic assessment should note any clinical deformity of the pelvis, limb-length discrepancy or malrotation. The pelvis is tested for rotational instability with pelvic compression and distraction tests. In the presence of signs suggestive of a genito-urinary injury, a retrograde urethrogram was performed.

At the clinical evaluation was always associated an accurate pelvis radiographic evaluation. If pelvic radiographs reveal obvious radiologic instability of the ring, an aggressive physical examination with compression and distraction will not provide additional information on injury severity [16]. Actually most of the pelvic trauma protocols included only an X-ray of the pelvis in a-p projection and a multislice CT scan with contrast imaging of the vessel. If it is possible, we prefer to complete the pelvic radiographic examination with 2 oblique projections: inlet (caudo-cranial with oblique beam at 45°) to evaluate iliac pelvic ring dislocations and outlet (cranial-caudal with oblique beam at 45°) to evaluate the sacro-iliac joints [17]. A hurriedly taken antero-posterior view of the pelvis in the trauma room is often inadequate and may fail to reveal posterior injury of the pelvic ring.

These fractures have been classified by Tile [18] in three main groups:

A-type stable fractures that do not need an urgent treatment.

B-type fractures with rotational instability, which are due to anterior–posterior trauma or due to lateral trauma by crashing forces. This type of fracture typically show lesion of the anterior ligament system of the pubic symphysis, lesion of the sacral spinosus ligament that provides the horizontal stability, lesion of the sacro-tuberosus ligament that provides the rotational stability and in the most serious cases lesion of the sacroiliac anterior ligament.

C-type fractures with vertical and rotational instability. This type of fracture typically show lesion of the sacro-tuberosus ligament, lesion of the sacroiliac interosseus ligament, lesion of the sacroiliac posterior ligaments and in the most serious cases lesion of the ileus-lumbar ligament with fracture of the transverse process of the fifth lumbar vertebra (tilt 5th).

In our opinion, this classification has a morphological and prognostic value and it is useful for the treatment.

External fixator is recommended in: type B1 fractures (open book) when the diastase of pubic symphysis is greater than 2.5 cm (in this case the anterior sacroiliac ligaments are involved), in type B2 fractures (closed book) where there is a partial lesion of the posterior sacroiliac ligaments and in type C1.1 fractures (extra articular fractures) when there is a partial congruence of the sacroiliac joint. Subsequent type of fractures show a major posterior instability, and in these cases, internal fixation of the sacroiliac joint is mandatory [19]. Injuries that frequently trigger retro peritoneal bleeding and hemodynamic instability are type B1 and type C fractures [20].

We observed 6 type B1.3, 13 type B2.1, 10 type B2.2, 6 type B1.2, and 6 type C1.1 fractures.

Always when there was a hemodynamic instability, an urgent stabilization of the fractures was performed by an anterior external fixation.

We used an external fixator (Stryker Hoffman II) that allows the independence use of the pins (cylindrical shaped auto-threading) to obtain an adequate positioning in the iliac wing. In emergency, the pins (5 mm diameter 180 mm length) are placed in the iliac crest just 1 cm above the SIAS with 40° of tilt from the vertical plane for the iliac wing conformation. Pin insertion on the iliac crest is not difficult and usually we do not use an image intensifier and it can be performed directly at the patient's bedside. After the pin positioning (two for each side), the transversal rods were mounted in a rectangular shape to have free access to the abdomen. In the following days after trauma, when the patient's condition is stable, the external fixator is checked and, if it is necessary, it is completed by positioning more pins. Placement of supra-acetabular fixation pins for external fixation can be performed safely with fluoroscopic guidance. It should be noted that on average the hip capsule extended about 16 mm proximal to the hip joint. Placement of pins at least 2 cm above the joint is recommended to prevent intra-capsular pin placement and potential joint sepsis. The

lateral femoral cutaneous nerve is at risk, and, thus, blunt dissection and use of appropriate soft tissue sleeves are recommended in an attempt to minimize potential injury to this structure. Gänsslen et al. reported an incidence of iatrogenic lesions of the lateral femoral cutaneous nerve in 4.5% of the patients of their series [21].

Biomechanics study on cadaver have shown that supra acetabular pin positioning ensure greater stability of the implant and helps the anterior pelvic ring closure [22].

We have used several types of external fixator trough the years (single and multiple…), and we think that the system stability does not depend on the type of external fixator but on many other factors such as pin positioning, type of mounting, type of fracture and patients factor (age, bone stock, BMI).

Fracture reduction maneuvers vary depending from the type of lesion: type B1 fractures (open book) are treated by compressing and twisting maneuvers; type B2 fractures (closed book) are treated by opposite maneuvers, type C fractures are treated by the same type of maneuvers and by pulling in oblique vertical direction. Pelvic ring fractures that show an evident bone dislocation must be reduced before insertion of the pin to avoid the necessity of large skin incision after fractures reduction. Early stabilization of the pelvic ring is the aim to achieve in urgent surgery so that bleeding can be stopped. After that we will take care of the best reduction and stability of the fracture once the patient's general conditions are stable. Therefore, in urgent surgery we usually place 2 fiches on the iliac crest and later we complete surgery by insertion of fiches above the acetabulum to guarantee a better stability of the pelvic ring. Furthermore, the insertion of pins above the acetabulum is sufficient to obtain a good stability of the pelvic ring so to avoid the need for further surgery.

In the most of the cases (43 patients), we used the external fixation as unique and definitive treatment; sometimes has been necessary little improvement of the external fixator some days after surgery when the patient's general conditions are better.

The type of treatment is chosen on the basis of:

- Type of pelvic fractures
- Type of patient (obese–non obese, osteoporosis)
- Surgeon's experience

We usually use the external fixator as a definitive treatment in type B fractures (rotational instability) and type C1.1 fractures where we achieve a good stability of the sacrum fracture. In four patients with unstable fractures of the posterior pelvic ring, we performed an internal fixator of the sacroiliac joint because the external was insufficient to achieve a good stability. In these patients, the external fixator was used as a temporary stabilization until the patient's general conditions allowed an internal fixation of the fractures (usually 7–10 days after) Fig. 1.

All patients were subjected to a clinical monitoring every 15 days to assess the status of the pin and to a radiographic check every 30 days.

After the pelvic stabilization, the patient mobilization starts as soon as possible according to the patient's general conditions and the fracture stability. Regarding to granting load we use a conservative protocol: in fractures type B1.2 and B2 was allowed a partial weight bearing after 20 days; in fractures type B1.3 weight bearing was allowed after 40 days. The external fixator was removed after an average of 60 days.

Results

To evaluate the clinical results, we used the Majeed evaluation schedule that assesses pain, standing position, sitting position, work efficiency, and sexual activity assigning a score to each of these parameters. A score greater than 85 is excellent, between 70 and 84 good, between 55 and 69 sufficient and less than 55 bad.

We have not recorded any death, the most fearsome complication. All patients at the time of our observation had hemodynamic instability that has been resolved with the positioning of the external fixator. When there was an abdominal organ rupture or a lesion of the main vessel the patients underwent to a laparotomy by the abdominal surgeon.

In 12 cases (29%), the score was excellent in 18 (44%) good in 7 cases (17%) sufficient and in 4 cases (10%) it was bad.

The bad results were due in one case to the premature removal of the external fixator with reopening of the pubic symphysis, and in two case to a late fracture stabilization (after 14 days and after 20 days).

Another bad result was a case of an obese and osteoporotic patient with a B1 fracture and laceration of vagina and consequent pelvis infection that it is not possible to perform an open stabilization of the pubic symphysis.

The sufficient results were due to persisting chronic back pain or to an impairment of the ability to walk.

Excellent and good results were associated with a good reconstruction of the pelvic ring and to the absence of anterior and posterior (sacroiliac joints) pain Fig. 2.

The main complications were due to superficial pin track infection (grade 1–2) (35%). These complications were mainly due to an excessive skin traction at the level of pin insertion; in these cases, we made small skin incisions under local anesthesia and oral antibiotic therapy for few days. Only in three cases were necessary the pins' removal. Osteomyelitis did not develop in any case.

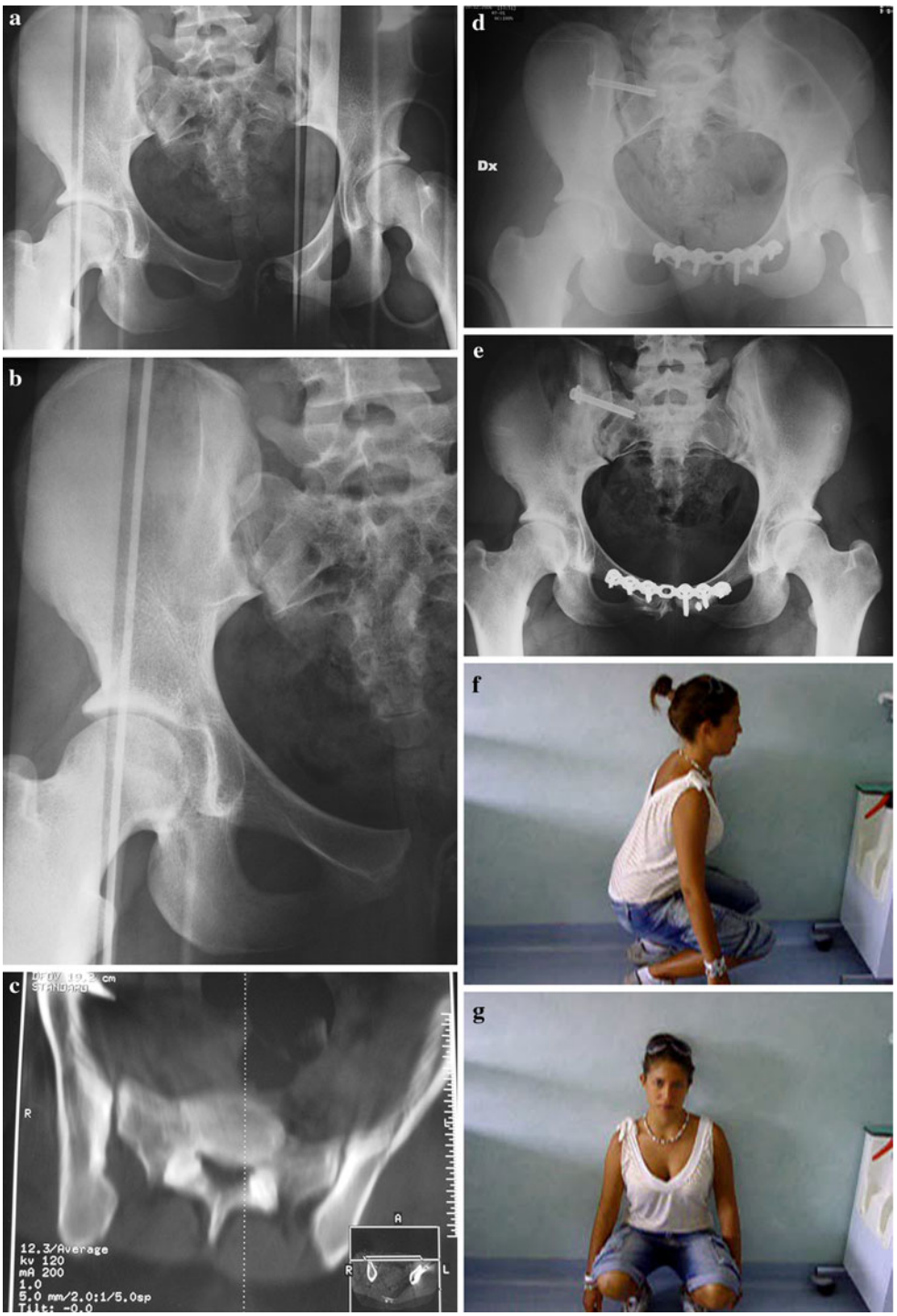

Fig. 1 **a**, **b** A 18-year-old woman had a traffic road accident sustaining a closed pelvic fracture (type C1,2) and an exposed tibial fracture (Gustilo grade 1) due to **a**. **c** Preoperative X-ray evaluation and CT scan show the lesion of the sacro-iliac ligaments (vertical instability). In this type of lesion, the external fixation is insufficient to achieve a good stability and an internal fixation of the sacro-iliac joint is required. As shown in the figure, CT image in this patient was performed by a temporary pelvic stabilization with an external fixation. **d**, **e** The definitive treatment of this type C fracture is open reduction and internal fixation: in this case, we performed a screw fixation of the sacro-iliac joint and a plate fixation of the pubic symphysis. Postsurgical X-ray (**e**). X-ray evaluation after 10 months from the injury that shows a good reconstruction of the pelvic ring (**f**). **f**, **g** Clinical evaluation after 10 months from the injury that shows a full functional recovery

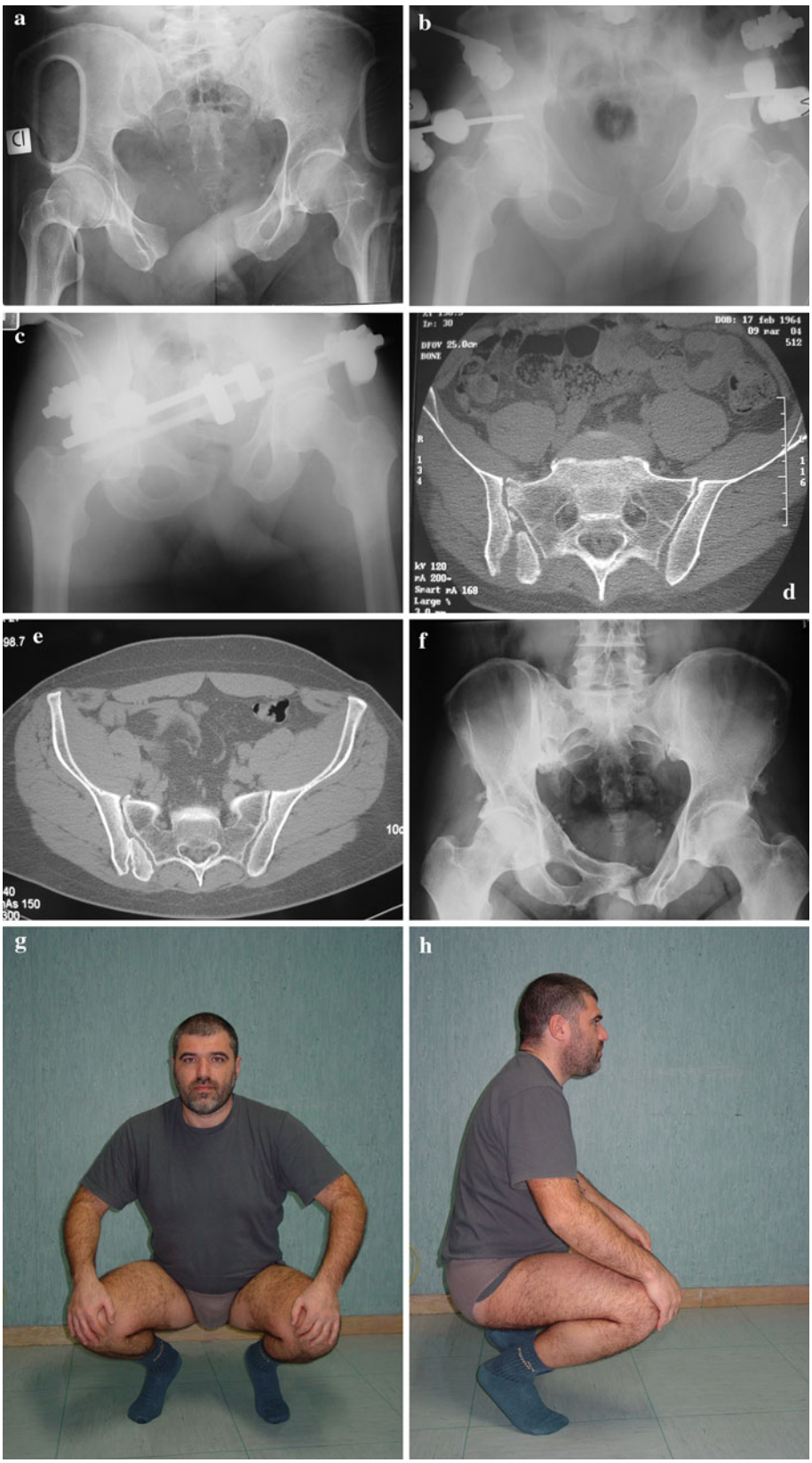

Fig. 2 **a** A 40-year-old man had a motorcycle accident, sustaining a type B1,1 (*open book*) injury to the pelvis (with the fracture of the posterior part of the iliac wing) and an exposed tibial fracture (Gustilo grade 2). **b** The pelvic fracture was treated by urgent external fixation. Post-surgical X-ray check after the urgent stabilization. **c** Five days after the injury, we made an improvement of the fixation in order to obtain a better fracture reduction. The post-surgical X-ray shows a good reconstruction of the pelvic ring. **d** Postoperative CT evaluation after 7 days that shows a good reconstruction of the pelvic ring. **e** CT evaluation after 8 months shows the fracture healed. **f** X-ray evaluation after 5 years from the injury. **g** Clinical evaluation after 5 years from the injury that shows a full functional recovery

Pins aseptic mobilization occurred in seven cases, and it was due to wrong positioning (transcortical) on the iliac wing. None of the supracetabolar pins had an aseptic mobilization. We never had non-union or neurologic complications.

Discussion

Pelvic fractures mainly are due to high-energy trauma, and usually they are associated with multiple injuries (fractures, chest lesions, abdominal lesions, and cerebral trauma). In this lesion, the mortality rate ranged from 5 to 42% and often it is due to massive hemorrhagic shock [4–6]. The retro-peritoneal space is a virtual cavity whose ability to accommodate a certain volume of blood depends on the tension generated by the abdominal muscles (intra-abdominal pressure); the hematoma is contained by the abdominal wall and the limited pelvic volume [23]. When the pelvis is fractured, more blood is allowed to collect in the retro-peritoneal space due to the pubic symphysis diastasis: Baquè has showed a diastasis pubic symphysis of 5 cm result in increased pelvic volume of 20.8% [24]; in a similar study, Moos has showed that for every centimeter of diastasis occurs an increase of 4.8% from the same volume [25]. The increase in the volume pelvic determines an increase in bleeding due to the sharp fall of intrapelvic pressure.

The management of politraumatized patients requires a multidisciplinary approach involving various specialists (medical emergency, anesthetist, orthopedic surgeon, neurosurgeon, and radiologist) according to a precise algorithm treatment [16]. Once the patient has come in, the shock-room priority is the restoration and maintenance of the vital functions (airways, breathing, circulation) control blood loss, as well as the execution of first level checks (chest rx, column rx, pelvis rx, pelvic ultrasound (FAST), and head CT scan).

In presence of a pelvic fracture, we must determine whether the fracture is mechanically stable and if the patient is hemodynamically stable.

Unstable pelvic fracture and hemodynamic instability require an urgent stabilization of the pelvic fracture as a fundamental part of the resuscitation maneuvers to break down the early mortality after trauma [15]. Pelvic stabilization, reducing the pelvic volume and bleeding from the stumps of fracture determines the arrest of the hemorrhage, as evidenced by the sharp decline in the number of transfusions in postoperative period. In these cases, there is an absolute indication for an urgent pelvic stabilization (as soon as possible).

Pelvic stabilization, whether temporary or permanent, allows to control the bleeding because it (1) leads to a reduction in the volume pelvis with a containment on the retro-peritoneal hematoma (2) reduces bleeding from the fracture fragments (3) reduces motility fracture promoting the blood clotting. The stabilization of the pelvis also makes it easier to manage the patient and his mobilization for the implementation of subsequent investigations.

In our experience, external fixator, for its characteristics, represents the gold standard approach for the urgent stabilization of these lesions, and, for most of them, it can be used as the definitive treatment.

External fixation is a quick and easy procedure for pelvic fractures stabilization for surgeons with experience with this technique.

Note that to get a good result in the long term is needed:

- A precise indication for surgery: in fractures with a severe posterior instability the external fixator does not provide an adequate mechanical stabilization and an internal fixation is necessary Fig. 3.
- Proper surgical technique: in urgent the external fixator positioning must be fast and the goal is to close and stabilize the pelvic fracture; in the days after the implant must be reviewed and the objective is the fracture reduction and its maintenance (we always place the soparacetabolar pins).
- Good cooperation of the patient, for the cleaning of the pins on alternate days and for the timing of weight bearing on the lower limbs. This will maintain low rates of infection and of other complications attributed to the use external fixation.

A laparotomy is required only in the presence of lesions of the abdominal organs or main vessel (iliac, femoral arteries…). In literature, the most debated point is "when" to perform the laparotomy whether before or after the pelvic stabilization [26]. As showed by Ghanayem [27], in the presence of an unstable pelvic fracture, performing a laparotomy determines an increase in the volume pelvis and the loss of tamponante effect exercised by the abdominal wall ("tension band effect") and the bleeding becomes uncontrollable. Therefore, even in the presence of lesions of the abdominal organs, it is absolutely necessary to do the pelvic stabilization before or during the laparotomy. The external Fixator positioning require only few minutes and does not obstruct the surgeon during the revision of the abdominal cavity.

Patients who remain hemodynamically unstable after external stabilization and other resuscitative measures but have no major intraperitoneal bleeding are potential candidates for pelvis angiography [16, 28, 29]; we must remember that, as evidenced by Moss [25], the source of bleeding is arterial blood (glutee arteries) in less than 20% of the cases. Minor arterial bleeding could be treated with a selective embolization of the vase harmed.

The rationale behind pelvic packing derives from the fact that the major source of hemorrhage from pelvic ring

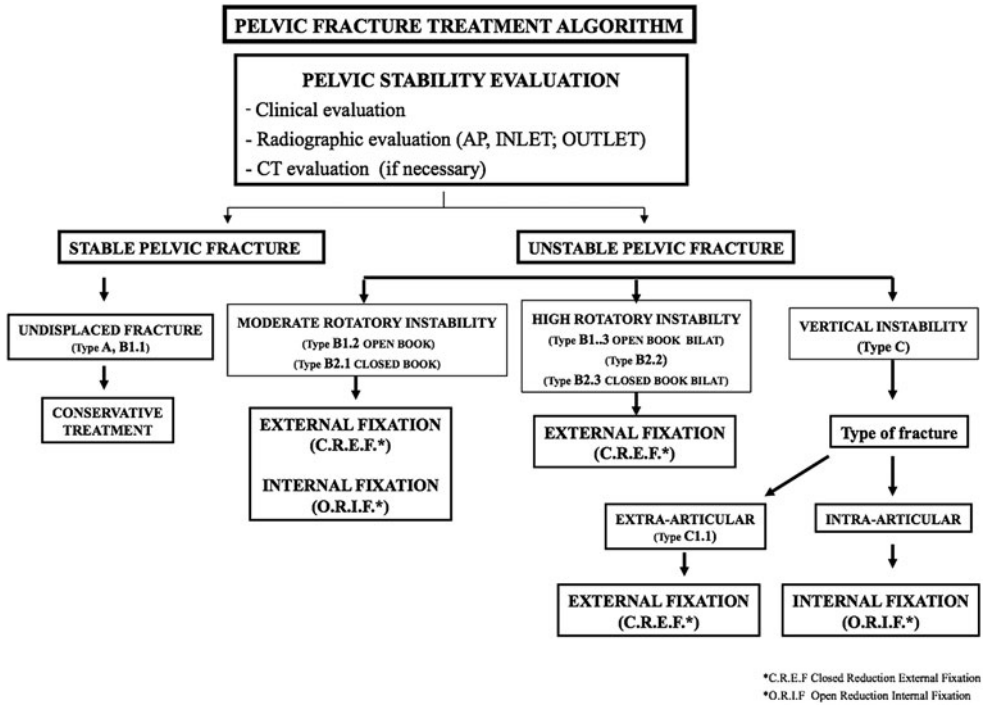

Fig. 3 Treatment algorithm of the pelvic ring fracture

injury is venous. Bleeding from the retroperitoneal lumbosacral venous plexus usually is stopped with the stabilization of the fracture of the pelvis. We think that pelvic packing should be considered only in patients that have a severe hemodynamic instability after fixing the pelvis due to retroperitoneal bleeding. In our trauma protocol, this procedure is performed from the abdominal surgeon. We have not ever used this technique in our series of patients.

In conclusion, the external fixation, temporary or permanent, is a real life-saving method in politraumatized patient with pelvic fracture; it is a little invasive procedure, fast running in skilled hands, that allows a good mechanical stability. The external fixation allows the possibility of subsequent changes and it can also be associated with other osteosynthesis methods. This technique also leaves intact the possibility of revising the abdominal cavity if it is necessary. Moreover, the results obtained by this method, 83% between good and very good, show that external fixation, used as a definitive method, has proven to be valuable, effective, and free of major complications.

Conflict of interest None.

References

1. Coppola PT, Coppola M (2000) Emergency department evaluation and treatment of pelvic fractures. Emerg Med Clin North Am 18(1):1–27
2. Biffl WL, Smith WR, Moore EE, Gonzalez RJ, Morgan SJ, Hennessey T, Offner PJ, Ray CE Jr, Franciose RJ, Burch JM (2001) Evolution of a multidisciplinary clinical pathway for the management of unstable patients with pelvic fractures. Ann Surg 233(6):843–850
3. Flint L, Babikian G, Anders M, Rodriguez J, Steinberg S (1990) Definitive control of mortality from severe pelvic fracture. Ann Surg 211(6):703–706
4. Heetveld MJ, Harris I, Schlaphoff G, Sugrue M (2004) Guidelines for the management of haemodynamically unstable pelvic fracture patients. ANZ J Surg 74(7):520–529
5. Ertel W, Eid K, Keel M, Trentz O (2000) Therapeutical strategies and outcome of polytraumatized patients with pelvic injuries a six-year experience. Eur J Trauma 26:278–286
6. Katsoulis E, Giannoudis PV (2006) Impact of timing of pelvic fixation on functional outcome. Injury 37(12):1133–1142 Epub 2006 Nov 7
7. Gilliland MD, Ward RE, Barton RM, Miller PW, Duke JH (1982) Factors affecting mortality in pelvic fractures. J Trauma 22(8):691–693
8. Rothenberger DA, Fischer RP, Strate RG, Velasco R, Perry JF Jr (1978) The mortality associated with pelvic fractures. Surgery 84(3):356–361
9. Brotman S, Soderstrom CA, Oster-Granite M, Cisternino S, Browner B, Cowley RA (1981) Management of severe bleeding in fractures of the pelvis. Surg Gynecol Obstet 153(6):823–826
10. Routt ML Jr, Simonian PT, Swiontkowski MF (1997) Stabilization of pelvic ring disruptions. Orthop Clin North Am 28(3):369–388
11. Ben-Menachem Y, Coldwell DM, Young JW, Burgess AR (1991) Hemorrhage associated with pelvic fractures: causes, diagnosis, and emergent management. AJR Am J Roentgenol 157(5):1005–1014
12. Brown JJ, Greene FL, McMillin RD (1984) Vascular injuries associated with pelvic fractures. Am Surg 50(3):150–154

13. Tile M (1988) Pelvic ring fractures: should they be fixed? J Bone Joint Surg Br 70(1):1–12
14. Flint LM Jr, Brown A, Richardson JD, Polk HC (1979) Definitive control of bleeding from severe pelvic fractures. Ann Surg 189(6):709–716
15. Meighan A, Gregori A, Kelly M, MacKay G (1998) Pelvic fractures: the golden hour. Injury 29(3):211–213
16. Mohanty K, Musso D, Powell JN, Kortbeek JB, Kirkpatrick AW (2005) Emergent management of pelvic ring injuries: an update. Can J Surg 48(1):49–56
17. Mostafavi HR, Tornetta P 3rd (1996) Radiologic evaluation of the pelvis. Clin Orthop Relat Res 329:6–14
18. Pennal GF, Tile M, Waddell JP, Garside H (1980) Pelvic disruption: assessment and classification. Clin Orthop Relat Res 151:12–21
19. Kellam JF, McMurtry RY, Paley D, Tile M (1987) The unstable pelvic fracture. Operative treatment. Orthop Clin North Am 18(1):25–41
20. Evers BM, Cryer HM, Miller FB (1989) Pelvic fracture hemorrhage. Priorities in management. Arch Surg 124(4):422–424
21. Gänsslen A, Pohlemann T, Krettek C (2006) Supraacetabular external fixation for pelvic ring fractures. Eur J Trauma 32:489–499
22. Kim WY, Hearn TC, Seleem O, Mahalingam E, Stephen D, Tile M (1999) Effect of pin location on stability of pelvic external fixation. Clin Orthop Relat Res 361:237–244
23. Huittinen VM, Slätis P (1973) Postmortem angiography and dissection of the hypogastric artery in pelvic fractures. Surgery 73(3):454–462
24. Baqué P, Trojani C, Delotte J, Séjor E, Senni-Buratti M, de Baqué F, Bourgeon A (2005) Anatomical consequences of "open-book" pelvic ring disruption: a cadaver experimental study. Surg Radiol Anat 27(6):487–490
25. Moss MC, Bircher MD (1996) Volume changes within the true pelvis during disruption of the pelvic ring–where does the haemorrhage go? Injury 27(Suppl 1):S-A21–S-A23
26. Grimm MR, Vrahas MS, Thomas KA (1998) Pressure-volume characteristics of the intact and disrupted pelvic retroperitoneum. J Trauma 44(3):454–459
27. Ghanayem AJ, Wilber JH, Lieberman JM, Motta AO (1995) The effect of laparotomy and external fixator stabilization on pelvic volume in an unstable pelvic injury. J Trauma 38(3):396–400
28. Cook RE, Keating JF, Gillespie I (2002) The role of angiography in the management of haemorrhage from major fractures of the pelvis. J Bone Joint Surg Br 84(2):178–182
29. Gänsslen A, Giannoudis P, Pape HC (2003) Hemorrhage in pelvic fracture: who needs angiography? Curr Opin Crit Care 9(6):515–523