DOI: https://doi.org/10.26676/jevtm.22378

Anatomy and Classification of Pelvic Trauma

Jacopo Giuliani, Riccardo Guelfi, Camilla Cremonini, Dario Tartaglia, Giuseppe Zocco, Massimo Chiarugi and Federico Coccolini

General, Emergency and Trauma Surgery Department, Pisa University Hospital, Pisa, Italy

Pelvic fracture is one of the most complex injuries in trauma treatment. Bleeding continues to be one of the primary causes of death from pelvic fracture, and the severity of bleeding is not necessarily correlated with the fracture pattern. The priorities in managing pelvic fractures include controlling bleeding. Historically, classification systems only consider the anatomical fracture pattern, which does not correlate with the outcomes. The World Society of Emergency Surgery (WSES) classification considers both the pelvic fracture pattern and the hemodynamic condition of the patient. Vascular injuries caused by pelvic fractures are potentially lethal because they often manifest as non-compressible multifocal venous bleeding (80–85% of pelvic bleeding) and less frequently as arterial bleeding (15–20% of pelvic bleeding). The presence of vascular injury and open pelvic fractures are independent factors contributing to mortality. Another fundamental factor in the management of pelvic vascular trauma is time [1]. In this context, the assessment of potentially significant vascular injury and timely hemorrhage control should be the highest priorities in the acute management of these injuries. Classification of pelvic injuries that considers both the fracture pattern and the hemodynamic status of the patient, such as the WSES classification, appears to have greater utility in clinical practice compared to the diffused anatomical classification.

Keywords: *Pelvic Fracture; Blunt Trauma; Hemodynamic Status; Bleeding; Vascular Injuries*

Received: 8 February 2024; Accepted: 13 February 2024

INTRODUCTION

Pelvic fracture is one of the most complex injuries in trauma treatment and is often the result of high-energy blunt trauma, accounting for approximately 3% of all skeletal injuries [2–4]. Patients are typically young and exhibit a high Injury Severity Score (ISS). Mortality rates remain elevated, ranging from 5 to 16%, particularly in patients with hemodynamic instability and severe associated injuries [5–7].

Bleeding continues to be one of the primary causes of death from pelvic fracture, and the severity of bleeding is not necessarily correlated with the fracture pattern. In patients with pelvic trauma, the prognosis is more closely linked to the severity of pelvic vascular injury than to pelvic ring fractures [8]. The initial management of pelvic trauma primarily focuses on physiological alterations and associated injuries, placing less emphasis on fracture patterns. The priorities in managing pelvic fractures include controlling bleeding, stabilizing hemodynamics, correcting coagulopathy and physiology, followed by achieving definitive mechanical stabilization of the pelvic ring.

Historically, the Young–Burgess [9] and Tile [10] classifications are the two most commonly recognized in the literature. These two classification systems only consider the anatomical fracture pattern, which does not correlate with the outcomes of patients with pelvic trauma. Rommens et al. [11] recently developed a radiographic classification (anatomical fracture pattern) for managing fragility fractures of the pelvis (FFPs) [11,12].

In 2017, the World Society of Emergency Surgery (WSES) published its guidelines for the classification and management of pelvic trauma. The WSES classification categorizes pelvic trauma injuries into mild, moderate, and severe, taking into consideration both the pelvic fracture pattern and the hemodynamic condition of the patient [13]. Pelvic fractures may be open or closed. Open pelvic fractures are relatively rare but more complex due to concurrent internal and external bleeding [14]. They are also usually associated with the onset of infection that may progress to sepsis, contributing to mortality [4,15–18]. Sepsis is associated with only 2–4% of all pelvic fractures but carries a mortality rate of up to 45% [19–21]. Therefore, an open pelvic fracture can be regarded as a specific pattern of disease with distinct injury severity and treatment strategies [22].

Corresponding author:

Federico Coccolini MD, General, Emergency and Trauma Surgery, Pisa University Hospital, Via Paradisia 1, 56100, Pisa, Italy.

Email: federico.coccolini@gmail.com

YOUNG–BURGESS CLASSIFICATION

The Young–Burgess classification (Figure 1) categorizes pelvic fractures according to the mechanism of injury [9]:

- Antero-Posterior Compression (APC):
  - APC I: less than 2.5 cm of widening of the pubic symphysis with no posterior instability, both clinically and radiographically;
  - APC II: widening of the pubic symphysis and posterior pelvic instability due to the rupture of the anterior sacroiliac complex;
  - APC III: associated with complete posterior ligamentous disruption.
- Lateral Compression (LC): LC injuries occur when a force, applied laterally and directed medially, is exerted on the pelvis. Fractures are more common with LC injuries compared to APC injuries.
  - LC I: lateral force applied to the back of the pelvis, representing a spectrum of injuries. The severity of sacral injury varies from an incomplete anterior iliac wing fracture to a complete sacral fracture, depending on the amount of energy applied to the pelvis at the time of injury. The degree of pelvic instability correlates with the severity of the injury, and there might be a role for stress radiographs in classifying this instability;
  - LC II: sacral fracture, rupture of the sacroiliac ligament and joint, or a crescent-shaped fracture dislocation of the ilium;
  - LC III: injuries result from a greater force. Ipsilateral internal rotation of the hemipelvis causes injuries to the contralateral hemipelvis in the form of anterior sacroiliac ligament rupture and injury to the sacrospinous and sacrotuberous ligaments.
- Vertical Shear (VS): These injuries result from an axial force applied to one or both hemipelvis lateral to the midline. The sacrum is pushed downward, causing complete ligamentous injury. Pelvic ring fracture may be present instead of ligamentous injury.
- Complex: A combination of the three primary patterns (APC, LC, or VS). Most of them result from combined LC injuries with APC or VS patterns.

TILE CLASSIFICATION

The Tile Classification (1980) is based on the type of mechanical instability of the pelvic ring [10].

- Type A: does not involve the pelvic ring itself and it is mechanically stable;
- Type B: rotational instability;
- Type C: vertical instability.

ROMMENS CLASSIFICATION FOR FFPS

The Rommens Classification is a classification for managing FFPs resulting from low-energy impacts (typically in elderly patients). It is based on morphological criteria and corresponds to the degree of instability of the pelvis [11,12].

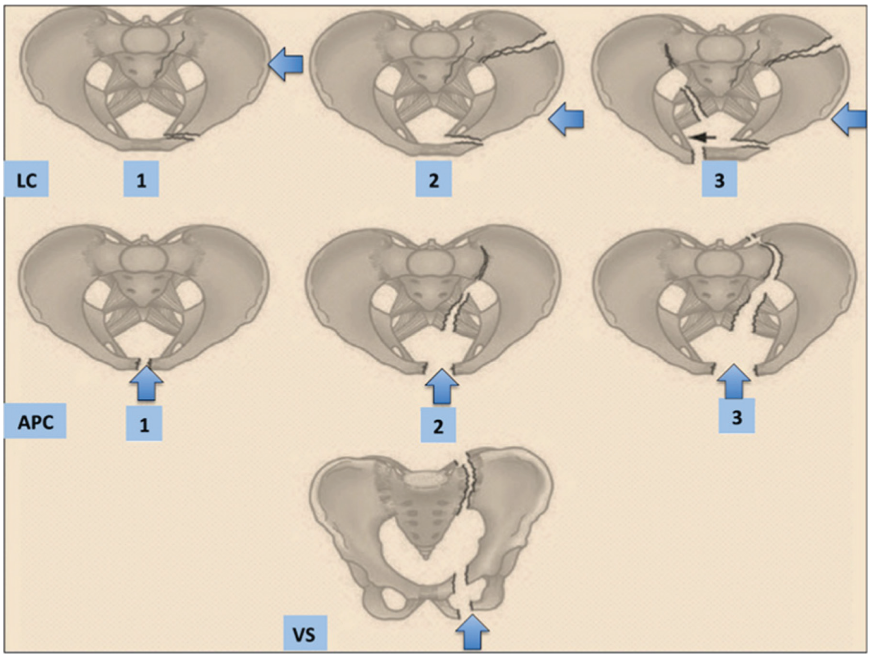

Figure 1 Young–Burgess classification for skeletal pelvic lesions.

Credit: Reproduced from Coccolini, F. et al. World J Emerg Surg. 2017;12:1–18, under CC BY 4.0 (http://creativecommons.org/licenses/by/4.0/).

- FFP type I:
  - a: unilateral anterior pelvic ring disruption;
  - b: bilateral anterior pelvic ring disruption;
- FFP type II:
  - a: dorsal non-displaced posterior injury;
  - b: only sacral crush with anterior disruption;
  - c: non-displaced sacral, sacroiliac, or iliac fracture with anterior disruption;
- FFP type III:
  - a: displaced unilateral ilium fracture and anterior disruption;
  - b: displaced unilateral sacroiliac disruption and anterior disruption;
  - c: displaced unilateral sacral fracture together with anterior disruption;
- FFP type IV:
  - a: bilateral iliac fractures or bilateral sacroiliac disruptions together with anterior disruption;
  - b: spinopelvic dissociation together with anterior disruption;
  - c: a combination of various posterior instabilities together with anterior disruption.

WSES CLASSIFICATION

The WSES classification takes into account both the anatomical pattern of pelvic fracture and physiological changes in the patient (hemodynamic stability or instability). The WSES Classification divides pelvic ring injuries into three classes (Table 1):

- Minor (WSES Grade I): hemodynamically and mechanically stable injuries (APC 1 and LC 1);
- Moderate (WSES Grades II and III): hemodynamically stable and mechanically unstable injuries (APC 2–3 and LC 2–3);
- Severe (WSES Grade IV): hemodynamically unstable injuries regardless of mechanical status.

As previously mentioned, the ATLS definition considers a patient "hemodynamically unstable" when blood pressure <90 mmHg and heart rate >120 bpm, with evidence of cutaneous vasoconstriction (cold, moist, reduced capillary refill), an altered level of consciousness and/or dyspnea [23].

Based on this classification, WSES has provided a management algorithm for patients with pelvic trauma [13].

DISCUSSION

The management of pelvic trauma continues to be a challenge. Pelvic fractures are often the result of high-energy impact and are generally associated with multisystem injuries and catastrophic bleeding. Most deaths related to pelvic fractures have been caused by associated injuries (i.e., brain trauma) [24–26]. Vascular injuries caused by pelvic fractures are potentially lethal because they often manifest as non-compressible multifocal venous bleeding (80–85% of pelvic bleeding) and less frequently arterial bleeding (15–20% of pelvic bleeding). In pelvic trauma, hemorrhage is indeed the most common cause of preventable death [8]. However, the Young–Burgess and Tile classification models do not correlate with the number of transfusions and do not show a consistent correlation with the need for urgent embolization.

The WSES classification of pelvic trauma, in addition to pelvic fracture stability, takes into consideration the hemodynamic conditions of the patient, allowing for an approach that directly targets the stabilization of hemodynamics and the control of pelvic bleeding.

Wang et al. [27], in line with the WSES classification, confirm that in patients with pelvic trauma mortality rates increase significantly with the severity of the injury class (from minor to severe injuries). They also note that the stability/instability of the pelvic ring does not have a significant impact on mortality. Furthermore, Wang et al. highlight the presence of vascular injury and open pelvic fractures as independent factors contributing to mortality [27]. Pelvic vascular injuries have been identified in 7–10% of stable pelvic fractures, often considered minor injuries and typically managed conservatively. Some of these fractures may even require angiographic embolization. Not only should the mechanical stability be assessed, but the associated vascular injury should also be considered in the management algorithm. The impact of mechanical pelvic stability on pelvic fracture mortality was statistically non-significant. However, the associated vascular injury served as an independent risk factor

Table 1 WSES Classification.

WSES Classification	*WSES Grade*	*Young–Burgess Classification*	*Hemodynamics*	*Mechanic*
Minor	WSES grade I	APC I – LC I	Stable	Stable
Moderate	WSES grade II	LC II/III – APC II/III	Stable	Unstable
	WSES grade III	VS – CM	Stable	Unstable
Severe	WSES grade IV	Any	Unstable	Any

for mortality. Unlike closed fractures, open pelvic fractures can lead to concurrent external bleeding, internal hemorrhage, associated injuries to the ano-rectal or urogenital regions, infections related to contaminated wounds, and other complications (sepsis and multi-organ dysfunction). Patients with open pelvic fractures exhibit significantly worse outcomes (higher mortality rate, increased infection rate, longer hospitalization time, and extended stay in the intensive care unit) compared to patients with closed pelvic fractures of the same WSES class (minor, moderate, and severe) [27].

Li et al. [22] evaluated the application of the WSES classification to patients with open pelvic fractures. In their study, they highlight that even in the case of open pelvic fractures, mortality, duration of intensive care unit admission, and hospitalization duration increase with the rising WSES grade of pelvic trauma. Furthermore, there is a correlation between open pelvic fractures and the development of sepsis. Sepsis proves to be an independent risk factor for mortality in patients with open pelvic fractures. Additionally, patients with sepsis exhibit significantly higher percentages of pelvic instability and associated vascular injuries compared to patients without septicemia. Besides hemorrhage control, the management of wound infection and the potential development of sepsis are crucial in the management of open pelvic fractures (broad-spectrum antibiotics for gram-positive and gram-negative bacteria, surgical debridement, and creation of a diverting colostomy). According to Li et al., the WSES classification is applicable when managing patients with open pelvic fractures; however, they emphasize that by adding the onset of sepsis as an additional variable (WSES classification + sepsis), a better prediction of mortality is achieved in cases of open pelvic fractures [22].

Another fundamental factor in the management of pelvic vascular trauma is time [1]. In this context, the assessment of potentially significant vascular injury and timely hemorrhage control should be the highest priorities in acute management [8].

In a retrospective cohort study, Spering et al. proposed a score to detect pelvic vascular injury in patients with severe pelvic fractures in pre-hospital trauma management. They identified nine predictive factors incorporated into a clinical score to identify patients with pelvic fractures at risk of significant vascular injury (P-VIS) [1].

- Patient condition:
  - Age ≥70 years;
  - High-energy trauma;
  - Penetrating trauma/open pelvic injury;
  - Shock index ≥1;
- Pre-hospital interventions:
  - Cardiopulmonary Resuscitation;
  - Replacement of >1 liter of fluid;
  - Intubation;
- Compensation:
  - Need for vasoactive drug therapy;
  - Residual shock (systolic blood pressure SBP ≤90 mmHg) under therapy.

A score of 0–2 points represents almost no risk of vascular injury, 3–5 points indicate a probable pelvic vascular injury, 6–8 points identify a very probable pelvic vascular injury, and 9 points represent an apparent vascular injury. This score is easy to apply and would suggest early pelvic stabilization through pelvic binding, as well as immediate transfer to a Level I Trauma Center and the subsequent early activation of an extended trauma team with vascular repair capabilities and high transfusion availability.

CONCLUSIONS

The severity of hemodynamic and physio-metabolic derangement represents a fundamental issue in the early management of patients with pelvic trauma.

Therefore, a classification of pelvic injuries that considers both the fracture pattern and the hemodynamic status of the patient, such as the WSES classification, appears to have greater utility in clinical practice compared to the diffused anatomical classification.

Ethics Statement

(1) All the authors mentioned in the manuscript have agreed to authorship, read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.
(2) The authors declare that they have read and abided by the JEVTM statement of ethical standards including rules of informed consent and ethical committee approval as stated in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

REFERENCES

[1] Spering C, Lehmann W, Möller S, et al. The pelvic vascular injury score (P-VIS): a prehospital instrument to detect significant vascular injury in pelvic fractures. Eur J Trauma Emerg Surg Off Publ Eur Trauma Soc. 2023; doi: 10.1007/s00068-023-02374-x.
[2] Balogh Z, King KL, Mackay P, et al. The epidemiology of pelvic ring fractures: a population-based study. J Trauma-Inj Infect Crit Care. 2007;63:1066–72.

[3] Durkin A, Sagi HC, Durham R, Flint L. Contemporary management of pelvic fractures. Am J Surg. 2006;192:211–23.
[4] Grotz MRW, Allami MK, Harwood P, Pape HC, Krettek C, Giannoudis PV. Open pelvic fractures: epidemiology, current concepts of management and outcome. Injury. 2005;36:1–13.
[5] Arvieux C, Thony F, Broux C, et al. Current management of severe pelvic and perineal trauma. J Chir Viscerale. 2012;149:e227–38.
[6] Magnone S, Coccolini F, Manfredi R, et al. Management of hemodynamically unstable pelvic trauma: results of the first Italian consensus conference (cooperative guidelines of the Italian Society of Surgery, the Italian Association of Hospital Surgeons, the Multi-specialist Italian Society of Young. World J Emerg Surg. 2014;9:18.
[7] Perkins ZB, Maytham GD, Koers L, Bates P, Brohi K, Tai NRM. Impact on outcome of a targeted performance improvement programme in haemodynamically unstable patients with a pelvic fracture. Bone Jt J. 2014;96 B:1090–7.
[8] Wu Y-T, Cheng C-T, Tee Y-S, Fu C-Y, Liao C-H, Hsieh C-H. Pelvic injury prognosis is more closely related to vascular injury severity than anatomical fracture complexity: the WSES classification for pelvic trauma makes sense. World J Emerg Surg. 2020;15:48.
[9] Dalal SA, Burgess AR, Siegel JH, et al. Pelvic fracture in multiple trauma: classification by mechanism is key to pattern of organ injury, resuscitative requirements, and outcome. J Trauma. 1989;29:981–2.
[10] Tile M. Acute pelvic fractures: I. causation and classification. J Am Acad Orthop Surg. 1996;4:143–51.
[11] Rommens PM, Hofmann A. Comprehensive classification of fragility fractures of the pelvic ring: recommendations for surgical treatment. Injury. 2013;44:1733–44.
[12] Hotta K, Kobayashi T. Functional treatment strategy for fragility fractures of the pelvis in geriatric patients. Eur J Trauma Emerg Surg Off Publ Eur Trauma Soc. 2021;47:21–7.
[13] Coccolini F, Stahel PF, Montori G, et al. Pelvic trauma: WSES classification and guidelines. World J Emerg Surg. 2017;12:1–18.
[14] Fu C-Y, Huang R-Y, Wang S-Y, et al. Concomitant external and internal hemorrhage: challenges to managing patients with open pelvic fracture. Am J Emerg Med. 2018;36:1937–42.
[15] Fu G, Wang D, Qin B, et al. Modified classification and repair of perineal soft tissue injuries associated with open pelvic fractures. J Reconstr Microsurg. 2015;31:12–9.
[16] Tseng I-C, Chen I-J, Chou Y-C, Hsu Y-H, Yu Y-H. Predictors of acute mortality after open pelvic fracture: experience from 37 patients from a level I trauma center. World J Surg. 2020;44:3737–42.
[17] Naam NH, Brown WH, Hurd R, Burdge RE, Kaminski DL. Major pelvic fractures. Arch Surg. 1983;118:610–6.
[18] Sinnott R, Rhodes M, Brader A. Open pelvic fracture: an injury for trauma centers. Am J Surg. 1992;163:283–7.
[19] Rothenberger D, Velasco R, Strate R, Fischer RP, Perry JFJ. Open pelvic fracture: a lethal injury. J. Trauma. 1978;18:184–7.
[20] Dente CJ, Feliciano DV, Rozycki GS, et al. The outcome of open pelvic fractures in the modern era. Am J Surg. 2005;190:830–5.
[21] Yoshihara H, Yoneoka D. Demographic epidemiology of unstable pelvic fracture in the United States from 2000 to 2009: trends and in-hospital mortality. J Trauma Acute Care Surg. 2014;76:380–5.
[22] Li P-H, Hsu T-N, Kuo Y-C, et al. The application of the WSES classification system for open pelvic fractures-validation and supplement from a nationwide data bank. World J Emerg Surg. 2022;17:29.
[23] Committee of Trauma of ACS. Advanced Trauma Life Support (ATLS) Student Manual. 9th ed. Chicago: ACS; 2012.
[24] Lunsjo K, Tadros A, Hauggaard A, Blomgren R, Kopke J, Abu-Zidan FM. Associated injuries and not fracture instability predict mortality in pelvic fractures: a prospective study of 100 patients. J Trauma. 2007;62:687–91.
[25] Agri F, Bourgeat M, Becce F, et al. Association of pelvic fracture patterns, pelvic binder use and arterial angio-embolization with transfusion requirements and mortality rates; a 7-year retrospective cohort study. BMC Surg. 2017;17:104.
[26] Gustavo Parreira J, Coimbra R, Rasslan S, Oliveira A, Fregoneze M, Mercadante M. The role of associated injuries on outcome of blunt trauma patients sustaining pelvic fractures. Injury. 2000;31:677–82.
[27] Wang S-H, Fu C-F, Bajani F, et al. Accuracy of the WSES classification system for pelvic ring disruptions: an international validation study. World J Emerg Surg. 2021;16:54.