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Review

Pelvic Ring Fractures with Associated Intraperitoneal Injuries: Patterns, Predictors and Management Pathways: A Narrative Review

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ABSTRACT

Background: Although infrequent, Pelvic ring fractures are among the highest fatality injuries, particularly when combined with intraperitoneal trauma. With mortality driven by simultaneous retroperitoneal pelvic hemorrhage and co-existing intra-abdominal bleeding, creating conflicting priorities during early resuscitation.

Objective: The main purpose was to review injury patterns, predictors, diagnostic challenges and current treatment approaches for concurrent pelvic ring fractures with associated intraperitoneal injuries.

Methods: A narrative review of trauma orthopedic and acute care surgery literature was performed, focusing on pelvic anatomy, mechanisms of injury, imaging strategies, damage-control sequence and hemorrhage-control interventions.

Conclusions: Pelvic ring fractures with intraperitoneal injury represent a "two-cavity" hemorrhage phenotype requiring integrated, time-critical trauma pathways and coordinated multidisciplinary care.

Keywords: Pelvic ring fractures; Intraperitoneal trauma; Orthopedic

Background

Pelvic Ring Fractures, particularly those resulting from high-energy mechanisms, are a small proportion of overall trauma presentations. However, it carries excessive morbidity and mortality, driven by multifocal pelvic hemorrhage and the frequent coexistence of major extra-pelvic injuries. In patients presenting with polytrauma, intra-pelvic venous or arterial bleeding often arises alongside thoracic, abdominal and cranial lesions, which explain how these injuries still remain life-threatening despite modern resuscitation and evolving trauma systems[1,2].

The burden on healthcare facilities and the rate of mortalities was pretty much expressed by the number of Epidemiologic studies and registry-based data, most notably in unstable pelvic fractures complicated by hemorrhagic shock. It is important to note that pelvic fractures are not isolated skeletal events, as intra-abdominal injuries may accompany pelvic ring disruption in up to 20% of cases and are associated with significantly higher mortality. But still, no consistent "fracture-type-to-viscera" correlations are present[3].

Existing trauma literature on CT experience reinforces this association, as a considerable amount of cohorts showcased pelvic ring fractures and many clinically significant abdominal visceral injuries (e.g., splenic, renal and hepatic lacerations)[2].

Management, therefore, hinges on a critical prioritization strategies. While most active pelvic bleeding is venous, arterial bleeding may need the demand of transcatheter embolization, creating complex decision points when intraperitoneal injury mandates managing with urgent laparotomy[3,4].

Pelvic ring anatomy and adjacent structures

The pelvic ring is a sealed Oste ligamentous structure formed by the sacrum and the paired innominate bones (ilium, ischium and pubis); because it is a bony architecture, it has a limited intrinsic stability and maintenance of ring integrity depends on strong ligamentous restraints and clinically meaningful displacement usually reflects disruption at two or more sites. Posterior arch is largely centered on the sacroiliac (SI) joints and it is the predominant stabilizer, stabilizing roughly 60% of the overall pelvic stability. Its strength is in the interosseous and posterior SI ligaments, iliolumbar ligament and the Sacro tuberous/sacrospinous ligaments, which acts as a harmonized "network" that withstands both rotational and shear forces. On the other hand, the anterior arch is linked by the pubic symphysis, a 10-mm-wide fibrocartilaginous joint stabilized by four main ligaments (superior, inferior, anterior and posterior pubic ligaments). Evidently, the posterior pubic ligament relates to the pubic bladder/puboprostatic ligament, underscoring the close anatomic relationship between anterior ring disruptions and the neighboring lower urinary tract structures[5].

Surrounding the ring is a dense vascular and visceral environment, composed of the internal iliac artery and branches (including the superior gluteal, obturator and internal pudendal arteries) that course along the endopelvic surfaces, predisposing pelvic fractures to major hemorrhage. The pelvis also functions as a "pelvic bowl" with a near 1,500 cc capacity, which can expand with mechanical instability (e.g., symphyseal diastasis) and in most traumatic pelvic bleeding originates retroperitoneally and especially from venous plexuses and cancellous bone surfaces of the posterior elements, such as sacral fractures and SI disruptions[2,6,7].

Beyond its bone and ligament ring, the pelvis is predominantly an extraperitoneal compartment, that is located between the peritoneum internally and the transversalis fascia externally. Gender differences of the pelvis present as follows. In the male pelvis, the inferior extraperitoneal space is classically divided into anterior and posterior compartments by the rectovesical septum (Denonvilliers fascia), whereas in the female pelvis, a homologous section is formed by the rectovaginal septum. A Common ground in both genders, the anterior compartment includes the prevesical and perivesical (paravesical) spaces surrounding the bladder (with extension toward the uterus and vagina in the female gender), while the posterior compartment incorporates the perirectal and presacral spaces. The umbilicovesical fascia correspondingly envelops the urachus, obliterated umbilical vessels and bladder in both genders, helping to define the anterior planes of the pelvis. The prevesical, also known as the Retzius space, is situated between the pubis and bladder, containing fat, loose connective tissue and prominent venous plexus, that accounts for the tendency of prevesical hemorrhage or extraperitoneal urinary extravasation after sustaining pelvic trauma, as well as predictable tracking of fluid collections into contiguous perivesical, pararectal or presacral spaces on high-resolution CT imaging[8,9,10].

Posteriorly and laterally, the pelvic ring closely edges the rectum, mesorectum and presacral tissues in both genders, yielding many major venous channels vulnerable to injury. When dissecting immediately behind the presacral fascia, it exposes the median sacral vein and its communications forming the presacral venous plexus, which is a thin-walled network adherent to the sacral periosteum and it is a well-recognized source of severe hemorrhage whenever disrupted. Anteriorly, the consolidated relationship between the pubis and the bladder neck/urethra, together with the endopelvic fascia. In males, this relationship is mediated by the puboprostatic ligaments, whereas in females, the pubovesical ligaments anchor the bladder neck and urethra to the pubis, with close proximity to the cervix and anterior vaginal wall. Cadaveric dissection demonstrates that division of these ligamentous complexes exposes the underlying membranous urethra and bladder neck. In this region, the dorsal venous complex gets supplied by the deep dorsal vein of the penis in males or the deep dorsal vein of the clitoris in females, which lies underneath and adherent to the endopelvic fascia and communicates with vesical, uterine, vaginal or vesicoprostatic venous plexuses draining toward the internal iliac vein. Any disruption of this plexus in pelvic trauma can therefore result in significant retropubic bleeding, representing the female anatomical counterpart of injury to Santorini's plexus in males[11,12].

On a functional basis, the pelvis serves as a conduit for neuromuscular actions, as pelvic "spaces" are conceptualized as peritoneal depressions with a common muscular floor formed by the levator ani, while the inferior hypogastric plexus spans within deep extraperitoneal planes to supply the bladder, rectum and anorectal sphincters, underscoring how high-energy pelvic fractures may yield combined hemorrhagic, urogenital, bowel and a long-term functional consequences[12-14].

The patterns of pelvic ring fractures and adjacent intraperitoneal injuries:

Across the modern classifications (Young–Burgess/Tile), pelvic ring disruptions cluster mainly into anterior–posterior compression (APC "open-book"), lateral compression (LC), vertical shear (VS/Type C) and combined patterns. The adjacent intraperitoneal injury burden tends to track with overall energy and instability rather than any single fracture classification or type. In an enormous clinical study, intra-abdominal injury accompanies pelvic fractures in up to 20% of trauma cases and usually are associated with a younger age of presentation but higher mortality. And a one retrospective series found no consistent "signature" correlation between a specific Young–Burgess subtype and abdominal injuries that required urgent surgery[3].

Regardless, "high-risk" patterns emerge in the interface of the pelvic ring and intraperitoneal organs, with unstable pelvic ring fractures having a higher risk of vascularor visceral complications, APC injuries with pubic symphysis diastasis and lastly, displaced pubic rami are specifically linked to bladder and urethral trauma. Including the clinically decisive distinction that intraperitoneal bladder rupture is uncommon but typically operative, whereas extraperitoneal rupture predominates with anterior ring fractures[15]. From an intraperitoneal "co-injury" perspective, severely injured individuals with pelvic ring fractures show frequent solid-organ involvement (e.g., liver/spleen/kidney injuries reported alongside type B/C fracture distributions) and may even demonstrate levels of pelvic hemorrhage tracking beyond the pelvis into abdominal compartments, complicating interpretation of free fluid[16].

In principle, this is the reason why FAST can be deceiving in pelvic fracture patients (false positives prompting potentially unnecessary laparotomy and false negatives delaying needed intervention), reinforcing the role of early contrast CT as well as CT cystography when indicated to guide both pelvic pattern and intraperitoneal injury pathways[17].

Prioritization and Initial Resuscitation: "Bleeding Pelvis vs. Bleeding Abdomen"

In the event of a combined pelvic ring disruption and suspected intraperitoneal injury, the earliest minutes are dominated by damage control resuscitation (DCR) and rapid source identification because both the pelvis and abdomen can bleed "silently," theretofore the definitive treatments diverge. Overlapping DCR combines hemostatic transfusion (early blood products instead of crystalloids), with permissive hypotension when appropriate, in addition of active hypothermia prevention and rapid hemorrhage control by either operative and/or endovascular means. Modern massive transfusion protocols (MTPs) operationalize this approach by approximating whole blood with balanced components (often targeting RBC: FFP: Platelets ratio of 1:1:1), aiming to blunt trauma-induced coagulopathy and reduce progression to the lethal triad. In severe pelvic trauma particularly, early, structured resuscitation remains crucial because the pelvis can accommodate large-volume hemorrhage (on the order of liters) and hypotension may lag behind substantial blood loss. And early shock physiology (tachycardia, cool peripheries, elevated lactate/base deficit) should drive urgency more than a "normal" initial blood pressure[18].

The main or core triage problem " Is it a bleeding pelvis or a bleeding abdomen?" This is solved effectively using an "A-E" trauma sequence plus fast imaging and hemodynamic response to resuscitation. In an unstable pelvic fracture patient, E-FAST is a rapid rule-in tool for major intraperitoneal bleeding, but clinicians must account for inadequate sensitivity and potential false positives (e.g., tracking from retroperitoneal hemorrhage or bladder rupture). Significantly, quantifying hemoperitoneum improves decision-making: "abundant" hemoperitoneum (e.g., 3 positive E-FAST windows) correlates with a higher proportion of appropriate laparotomies than moderate hemoperitoneum[18,19].

Contrariwise, it has been demonstrated that for major pelvic fracture patients, a small or no free fluid makes an abdominal source of hemorrhage highly unlikely. In the case of shock, this should shift suspicion strongly towards primary pelvic bleeding source and justify pelvic-first hemorrhage control when immediate CT is hazardous. This is consistent with the broader principle that the persistently unresponsive hypotensive patient should undergo damage-control measures before CT because transport and delay can precipitate collapse. When physiology allows, contrast-enhanced whole-body CT is prioritized to list injuries and identify active bleeding. Several guidelines have recommended CT before angioembolization if the patient can tolerate it, provided scanning is rapid and does not delay hemostasis[18-20].

Definitive pathway selection in the early stages then follows the presumed bleeding compartment and source. Pelvic hemorrhage is most often venous/bony (plexus and cancellous bone), whereas in arterial bleeding (internal iliac branches and variants) accounts for a smaller but a critical subset that is frequently cited around 10–20% of severe hemorrhages and its response to mechanical stabilization alone is less likely. This distinctive pattern supports the early choice between preperitoneal pelvic packing (PPP) and angioembolization (AE). When PPP is designed to tamponade venous and bony bleeding rapidly through an extraperitoneal approach, it is particularly valuable when the patient remains unstable despite initial resuscitation, when venous/osseous bleeding is more likely or when use of interventional radiology is delayed or unavailable and it can be conducted alongside other damage-control steps (external fixation/binder and even concurrent laparotomy when needed)[4,21].

At the same time, in low-resource settings, this "speed and availability" advantage makes PPP a practical first-line option for unstable pelvic fracture bleeding control. In contrast, AE is the "gold standard" for controlling arterial pelvic bleeding, with high reported technical success and is typically triggered by CT contrast extravasation/arterial injury signs or persistent instability and ongoing transfusion needs despite initial mechanical/packing measures. The time-to-AE is not a trivial operational detail, meaning that delays to successful embolization are repeatedly associated with poorer outcomes, demonstrating that trauma systems frequently prioritize whichever hemorrhage-control treatment can be provided the quickest in their context[4,22].

When there is evidence of intraperitoneal injury (e.g., peritonitis, hemodynamic instability with clearly significant hemoperitoneum), damage-control laparotomy remains a non-negotiable and key aspect in combined injuries, as laparotomy alone does not treat pelvic venous plexus bleeding and may even reduce retroperitoneal tamponade. Therefore, many pathways emphasize simultaneous or immediately sequential pelvic stabilization with (binder/ex-fix) and/or PPP, followed by AE when arterial bleeding is demonstrated or when shock persists[21].

Eventually, for the extremis patient (near-arrest physiology) as a bridge to definitive hemorrhage control, REBOA in particular zone III for pelvic hemorrhage appears in modern evidence of damage-control toolkits, although its outcome benefit remains discussed and is highly dependent on minimizing occlusion time and rapidly transitioning to definitive control (PPP/AE)[18,23] **(Figure1)**.

Diagnostic Decision-Making: the role of different Imaging modalities (E-FAST, CT, DPL) and the Role of Clinical Judgment

In the case of a combined pelvic ring with the suspicion of intraperitoneal injury, the diagnostic strategy is deliberately physiology-led; imaging is used to rapidly identify (or confidently deprioritize) time-critical abdominal hemorrhage/viscus injury while avoiding delays to hemorrhage control. Contemporary algorithms therefore implant using E-FAST early during damage-control resuscitation and plain films, then "gate" CT to patients who are stable or at least transient responders; patients with persistent instability and convincing intra-abdominal pathology proceed to operative exploration even when imaging is incomplete or questionable. This logic is detailed in proposed management pathways where the choice between immediate exploration versus extended imaging depends primarily on the hemodynamic stability and suspected/confirmed surgical intra-abdominal injuries trigger immediate transfer to the OR (often paired with pelvic measures such as preperitoneal packing)[24].

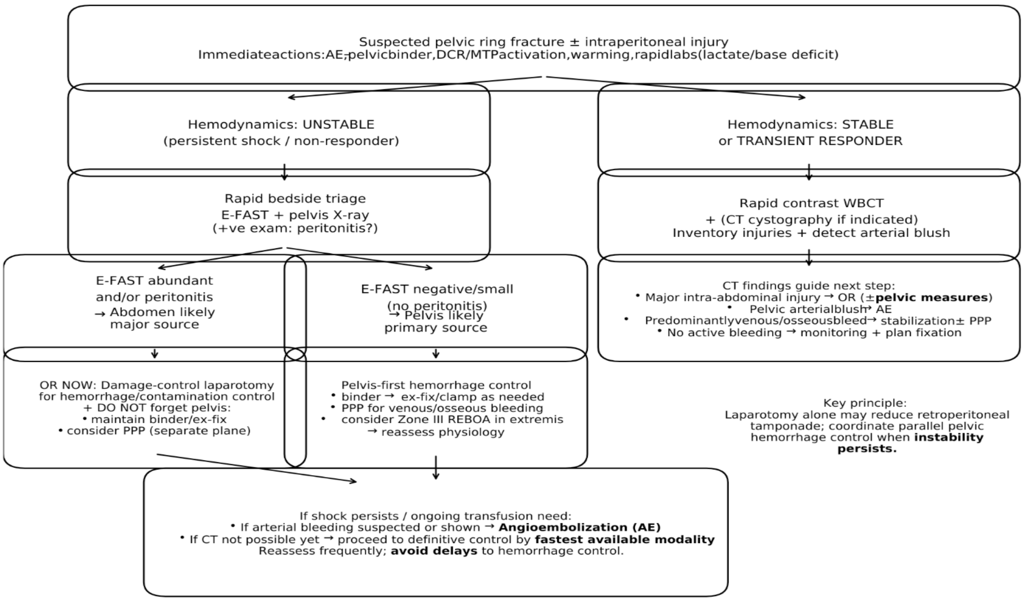

Figure 1: Decision pathway.

E-FAST is rapid, repeatable, bedside and most useful as a binary question in shock: "Is there a clinically significant hemoperitoneum/pericardial tamponade/hemothorax that changes the next step?" It is recommended to be used early in cases of unstable pelvic trauma workup to recognize life-threatening injuries and possible bleeding sources. However, its performance degrades in pelvic fracture populations: experts warn that sensitivity/specificity are reduced, with one study reporting false positives to be around 30.9% (with many leading to unnecessary laparotomy) and a false negatives rate of around 34.8% (delaying treatment)[17].

Accordingly, FAST is an indirect tool, meaning it detects free intraperitoneal fluid, not the bleeding vessel and it requires a minimum volume before becoming sonographically apparent; thus, in broader blunt trauma data, detectable thresholds on ultrasound are commonly in the range of 100–300 mL, creating a "blind window" early after injury. Therefore, FAST can be negative in important abdominal injury without hemoperitoneum and it can be positive for fluid that does not represent a significant surgical intraperitoneal bleeding. A practical refinement is serial FAST. Where in an observation of hemodynamically unstable blunt trauma patients, two sequential negative FAST exams were reported as adequate to accurately exclude clinically significant intra-abdominal bleeding as the source of instability (serial FAST sensitivity 100%, specificity 94% for clinically significant abdominal bleeding in that study) and adding diagnostic peritoneal aspirate (DPA) after two negative FASTs did not identify any additional abdominal source of shock. This reinforces a common bedside pivot: persistently unstable + repeatedly FAST-negative → actively search for pelvic (or other) hemorrhage and non-hemorrhagic shock etiologies, rather than perseverating on the abdomen[25].

Contrast-enhanced CT is the standard "injury inventory" tool once physiology permits, clarifying pelvic fracture morphology, retroperitoneal hematoma distribution, solid organ injury and signs of arterial hemorrhage (contrast extravasation/blush). In pelvic fracture care pathways, stable patients or who responded to resuscitation should undergo CT to evaluate any associated injuries. Similarly, damage-control algorithms propose the utilization of whole-body CT for hemodynamically stable or transient-responder pelvic fracture patients to define injury burden and guide next steps. CT should ideally be performed with IV contrast to identify active bleeding sources[17,24,26]. In team-based pelvic trauma guidance, the initial trauma CT contrast-enhanced specifically used to detect arterial extravasation and if present, it is considered a clear trigger to pursue embolization[26].

More importantly, CT findings must be interpreted in a clinical context. one a pelvic fracture analysis showcased "contrast blush" and angiographic intervention did not map 1:1: not all patients with blush required embolization and not all embolized patients had blush on CT; making decisions for angiography in blush-negative patients often driven by the degree/duration of hypotension and response to resuscitation and some patients with concurrent abdominal injuries required urgent laparotomy instead of embolization despite the CT results. [27] This reinforces that CT is highly informative but not a substitute for physiologic triage.

Diagnostic peritoneal testing remains highly sensitive for intraperitoneal blood, but its role has narrowed in a post CT/FAST era. It persists mainly as an adjunct when the patient is excessively unstable for CT and when FAST is negative/uncertain or when clinicians need a rapid answer to "abdomen vs not abdomen" to justify laparotomy versus pelvic-first hemorrhage control. It was shown that DPA was performed after two negative FASTs (where positive was defined as ≥10 mL aspirated blood), yet even "positive" DPAs were ultimately attributed to pelvic bleeding and did not change management, underscoring the risk of misleading positives when pelvic hemorrhage dominates. More broadly, DPA/DPL is also discussed to use in stable patients to help detect bowel/mesenteric injury (entities that can be diagnostically challenging), but this is a targeted rather than routine indication[25].

Given that imaging can miss early bleeding, retroperitoneal sources or hollow viscus injury, operative decisions must remain anchored to the clinical image. The presence of persistent hemodynamic instability despite adequate transfusion, escalating blood requirements, the presence of evolving peritonitis or rigidity, progressive abdominal distension and mechanisms indicating bowel or mesenteric disruption all are red flags that prompt rapid exploration, without waiting for CT and despite negative or inconclusive FAST results. In unstable pelvic fractures, algorithms reflect this regulation: suspected or confirmed intra-abdominal injury mandates exploratory laparotomy, with pelvic hemorrhage control performed in parallel when required[24].

In practice, the safest approach is sequential: repeat exams, repeat FAST when appropriate, use CT when physiology allows and escalate to operative exploration when discordance exists between "reassuring" imaging and a worsening physiologic/ abdominal exam.

Damage Control in Combined Pelvic and Intraperitoneal Trauma

The combined presentation of pelvic ring disruption with intraperitoneal injury presents a classic "two-cavity" hemorrhage problem, in which retroperitoneal bleeding driven by pelvic instability, which, as mentioned before, is predominantly venous or osseous, coexists with intraperitoneal hemorrhage or contamination requiring operative control. In this setting, damage control surgery is best executed as a tightly coordinated, physiology-driven sequence that prioritizes need of immediate pelvic volume reduction and hemorrhage tamponade while also simultaneously addressing time-critical abdominal pathology: early temporary pelvic stabilization (binder or sheet, followed by external fixation or pelvic clamp when indicated) is initiated and the patient is transferred to the operating room for parallel damage-control interventions, where preperitoneal pelvic packing targets the dominant pelvic bleeding source and may be performed during the same operative sitting as exploratory laparotomy and/or definitive pelvic stabilization[21]. Technically, PPP is performed through a short infra-umbilical/pubic incision into the preperitoneal space and when a midline laparotomy is required for intraperitoneal injury, it is deliberately created as a separate, more cranial incision to keep planes distinct and allow multiple teams to work concurrently[28].

Once the abdomen is opened, damage-control laparotomy proceeds with control of intraperitoneal hemorrhage and contamination (e.g., rapid control of hollow viscus spillage and temporization of solid-organ bleeding with packing such as perihepatic/perisplenic packing as needed), observed by temporary abdominal closure and return to ICU for ongoing damage-control resuscitation; during this phase, PPP "buys time" for correction of the lethal triad and, when arterial bleeding remains suspected or demonstrated, serves as a bridge to selective angioembolization[29,30].

The pathway is staged inherently when pelvic packs are not definitive therapy and typically require a scheduled second procedure for pack removal, with many protocols describing pad changes in the window of 24-48 hours as a part of a structured second-look operation; subsequent re-explorations (second-/ third-look) may be needed at 48-72 hours depending on patient's physiology and ongoing bleeding/infectious concerns[21,31]. Pelvic packing is generally removed once the physiologic dysfunctions (acidosis, hypothermia, coagulopathy) have resolved[29].

In practice, this sequence "stabilize → pack pelvis → laparotomy/pack abdomen as needed → temporary closure → resuscitate → staged re-exploration (remove/change packs, escalate to AE if persistent bleeding) → definitive fixation" compresses time to hemostasis, reduces mutually exclusive decision points between pelvis-first and abdomen-first strategies and operationalizes damage control principles for the combined bleeding pelvis/bleeding abdomen patient **(Figure 2)**.

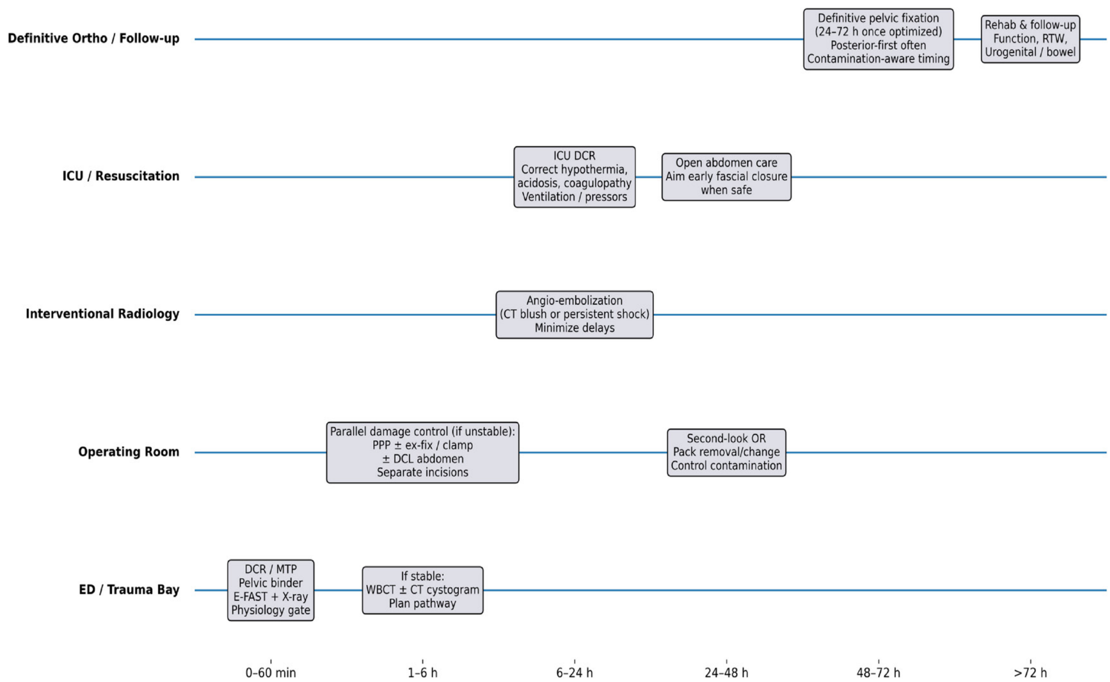

Figure 2: Damage control sequence

The Transition Phase: Definitive Pelvic Ring Fixation after Intraperitoneal Control

After time-critical intraperitoneal hemorrhage control and contamination management (repair/diversion, source control and planned re-exploration), Definitive pelvic ring focus of management shifts from "life-saving stabilization" to "durable anatomic stability but still remains physiology- and contamination-led: temporary measures (binder/external fixator/C-clamp/T-clamp) should be maintained only long enough for bridging the patient to a resuscitated, operable state, because prolonged circumferential compression risks soft-tissue injury (binders should generally be released the morning after injury if hemodynamics permit and then either converted to an external fixator or to be proceeded with definitive fixation depending on overall condition)[18].

Once stabilized, expert pathways describe definitive fixation being performed in the days following trauma, typically in a staged construct tailored to instability pattern, with more often starting with posterior fixation first (e.g., SI-region stabilization) followed by anterior ring fixation as needed for residual displacement/instability[19].

Practicing surgeons also commonly Favor the early definitive fixation, with many selecting a 24–36-hour window after resuscitation when the patient is physiologically optimized. Nonetheless, in patients with contaminated fields (bowel injury, open pelvic fracture with perineal/rectal/vaginal communication or ongoing pelvic packing), infection avoidance becomes the dominant restriction with pelvic packing carries substantial infection risk and therefore packs should be removed as early as it can (often <24 hours), re-packing should be avoided when possible and anterior ring ORIF particularly with plates may be postponed or avoided in "high-risk" contaminated scenarios in favor of temporizing/definitive external fixation or less invasive fixation strategies until source control and soft-tissue conditions are acceptable[18,32].

On the contrary, when contamination is addressed with appropriate debridement/irrigation and concomitant visceral repair, fixation can be safely incorporated: in extraperitoneal bladder rupture, the combined approach of bladder repair with anterior internal fixation was associated with fewer deep infections than non-repair/non-fixation strategies, supporting coordinated combined procedures when the field can be rendered adequately clean[18].

In terms of operative management, these competing priorities claim for deliberate ortho–general surgery "shared OR planning," aligning pelvic pack removal/second-look laparotomy timing with the definitive pelvic fixation when physiology permits, minimizing the need of repeated transports and maintaining abdominal access (e.g., using anterior–inferior external fixation constructs that do not obstruct laparotomy) while sequencing fixation to avoid hardware contamination and to capitalize on the same anesthetic episode whenever safe[19].

Outcomes in Combined Pelvic and Intraperitoneal Trauma

In combined pelvic ring disruption with concomitant intraperitoneal injury, outcomes are largely determined by the early "two-cavity" physiology (ongoing hemorrhage/contamination, shock and massive resuscitation) and by the downstream complications of a staged damage-control care, prolonged ICU exposure and the repeated returns to the OR. Short-term mortality remains driven by the same time-dependent pattern described in major trauma, early deaths from uncontrolled bleeding and later deaths from systemic complications. While the pelvic–abdominal combination increases the risk of organ failure because retroperitoneal hematoma, bowel edema and large-volume transfusion/fluids can precipitate intra-abdominal hypertension (IAH) and abdominal compartment syndrome (ACS). In a pelvic-fracture investigation, IAH and ACS were diagnosed in 9.7% and 1.1% respectively, with resuscitation volume over the first 24 hours correlating with an elevated intra-abdominal pressure and decompressive laparotomy (DL) producing substantial physiologic improvement in terms of oxygenation/ventilatory pressures, lactate, urine output but with persistent mortality in the sickest patients (15% after DL and 40% among ACS patients). Clinically, this is exactly where a combined pelvic + intraperitoneal trauma becomes high-risk for ARDS and multiple-organ dysfunction: even when DL relatively "works" physiologically, post-decompression deterioration can occur and in that sequence respiratory function worsened in several patients after DL, with deaths attributed either to respiratory/circulatory failure or presumed ARDS/reperfusion injury[33].

At the same time, the intraperitoneal component introduces infection and sepsis hazards (enteric contamination, open abdomen, prolonged packing/temporary closures), making the balance between definitive closure and avoiding recurrent IAH/ACS crucial. When pelvic packing and/or intraperitoneal contamination are present, an "open-abdomen" strategy with negative-pressure temporary abdominal closure is recommended rather than a definitive closure. This is attributed to the fact that these patients are considered high-risk for IAH/ACS and early fascial closure (within 2 days) is emphasized to improve outcomes and limit abdominal-wall morbidity. In a more broad severe abdominopelvic trauma population, the signal that pelvic fracture meaningfully contributes to ACS risk is invariant among 100 high-risk trauma patients with serial bladder pressure monitoring, primary ACS occurred in 28%, pelvic fracture was significantly associated with ACS and mortality among ACS patients was extremely high (82%)[33,34].

These short-term pathways also articulate abdominal wall complications: patients managed with open abdomen/negative-pressure therapy face risks of delayed closure, fascial retraction and later ventral hernia/abdominal wall dysfunction, so protocols that couple physiology-led decompression when needed with aggressive early closure are a paramount for promoting a survivorship burden. Over the long term, even when patients survive the acute phase and achieve bony union, combined pelvic + intraperitoneal trauma is frequently followed by a persistent limitation in function (pain, reduced mobility/endurance, impaired participation/return-to-work) and quality-of-life deficits that reflect both pelvic instability/neurologic–urogenital sequelae and the systemic insult of critical illness; these domains should therefore be tracked explicitly in follow-up (functional scores, work/participation, sexual and bowel/bladder function), because "survival" is often accompanied by durable disability and rehabilitation needs[33,35].

Limitations of Current Evidence and Directions for A dvancement

A persistent gap in combined pelvic–abdominal trauma is system variability: despite broadly shared damage-control principles, there remains to be a notable disagreement across centres (and even among expert pelvic surgeons) regarding acute pathways (e.g., packing-first vs angiography-first in the unstable patient), timing/sequence of fixation and thresholds for escalation all which reflect the reality that evidence-based pelvic ring practice guidelines are still limited and many decisions rely on low-level evidence plus local "expert opinion." and "surgeon preference" In an international survey, 38/45 (84%) management questions showed minimal-to-no agreement, including no agreement around preferred management of hemodynamically unstable pelvic ring injuries (angiography vs pelvic packing) and variability extended from acute instability through timing of definitive fixation and anterior/posterior fixation strategies[32].

This heterogeneity is amplified in the "two-cavity" phenotype (pelvis + intraperitoneal injury), where parallel teams must coordinate decisions under time pressure. Still, a lot of published algorithms remain separated (pelvic hemorrhage-focused or abdominal injury-focused) rather than fully integrated. Compounding this, comparative evidence is hard to interpret because pelvic hemorrhage studies often use non-uniform definitions and endpoints; contemporary reviews highlight that non-standardized reporting limits meaningful comparison between strategies such as packing and angioembolization and argue for shared performance indicators (including system metrics) rather than isolated modality success rates[29].

A practical future direction is therefore the development of a harmonious, combined pelvic–abdominal algorithms that explicitly encode: (1) physiology gates for CT vs OR, (2) rules for "parallelization" (PPP/ex-fix plus laparotomy when indicated), (3) contamination-aware fixation timing and (4) a common language of endpoints especially time-to-definitive hemorrhage control (including both OR and angiography time where relevant).

A second major gap is triage precision: teams still lack the bedside-ready scores that are both widely validated and reliably discriminate "predominantly venous/bony pelvic bleeding" from "arterial pelvic bleeding needing AE," and that simultaneously account for synchronous intraperitoneal hemorrhage/contamination. While prospective and observational work suggests potentially useful predictors (e.g., negative FAST, metabolic acidosis and transfusion requirement being associated with pelvic fracture–related arterial bleeding), these signs are not yet embedded into a universally adopted triage tool. In parallel, hemorrhage prediction tools (e.g., the Assessment of Blood Consumption (ABC) score and revised scores incorporating pelvic fracture) and newer AI-based models show promise for anticipating massive transfusion needs, but require broader validation and calibration in the specific subgroup of combined pelvic–abdominal trauma[27,29].

Accordingly, future directions should include (1) better triage scores tailored to a pelvic–abdominal "two-cavity" aspect in regards to physiology (integrating hemodynamics, FAST/CT signals, transfusion trajectory and contamination indicators), (2) pelvic trauma center models (regionalized pathways, 24/7 OR + IR capability and multidisciplinary pelvic teams) and (3) registry-based outcome research: multicenter prospective pelvic trauma registries have been advocated as a high-yield strategy to overcome low incidence and enable comparative effectiveness projects, with the explicit goal of generating practice guidelines that decrease variability and improve outcomes[32].

Eventually, registries should deliberately capture patient-centered and long-term domains (function, return-to-work, urogenital/bowel outcomes), because current success is still so frequently evaluated by radiographs rather than a validated functional objective recovery method, which is another gap highlighted in contemporary pelvic ring literature[36].

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