**Title: ICU rehabilitation and outcomes in elderly pelvic ring fractures due to high-energy trauma.**

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**Running Title :** ICU Rehabilitation and Outcomes of Older Patients

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***Abstract***

Pelvic fractures, accounting for 2–8% of skeletal injuries, present a significant burden in patients with trauma. High-energy incidents often result in severe pelvic trauma accompanied by comorbidities leading to high mortality rates. Managing these complications adds complexity to the treatment process, particularly in older patients who experience longer recovery times and higher injury severity. To improve the long-term quality of life, a multidisciplinary approach is essential. However, rehabilitation feasibility is influenced by the patient's condition and pelvic fixation stability, necessitating individualized treatment. This study investigated the rehabilitation status and long-term outcomes of older patients with severe polytrauma and pelvic ring fractures caused by high-energy trauma. The results revealed that 79.2% of the patients achieved full weight-bearing, with a median time of 41.5 days, and eventually 58.3% were discharged home. Complications were observed in 83.3% of the patients, with various challenges affecting successful home

discharge. Multidisciplinary rehabilitation programs are promising for optimizing outcomes and facilitating recovery in vulnerable patient populations. Still, larger, more focused studies are needed to gain more comprehensive insights into the treatment and recovery of older patients with pelvic ring fractures and severe polytrauma.

51 Understanding these factors is crucial for guiding clinical decision-making and improving
52 long-term outcomes in this population.
53
54 **Keywords:** pelvic ring fracture, older patients, rehabilitation, polytrauma, intensive care
55 unit
56

# 高エネルギー外傷による高齢者の骨盤輪部骨折における ICU でのリハビリテーションと転帰

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骨盤骨折は骨格損傷の 2～8%を占めるが、高エネルギー事故で生じる骨盤外傷にはしばしば高い死亡率につながる合併外傷を伴う。これらの合併外傷の管理は、状態の改善までに時間がかかり、外傷の重症度が高い高齢骨盤輪骨折においては特に治療経過を複雑にする。患者の長期的な QOL を向上させるためには、集学的アプローチが不可欠であることが知られている。また、集学的アプローチにおいて、患者の早期離床に向けたリハビリテーションの重要性は認識されている。しかしながら、高エネルギー外傷により、全身状態が不良となり、さらに体幹の安定性に寄与する骨盤輪骨折を有する患者においては、リハビリテーションは患者の状態や骨盤固定の安定性に影響されるため、個別化された治療が必要となる。本研究では、高エネルギー外傷による重症多発外傷および骨盤輪骨折を有する高齢患者のリハビリテーション状況と長期転帰について検討した。その結果、79.2%の患者が全荷重での移動が可能になり、達成までの期間は中央値で 41.5 日、最終的に 58.3%が自宅退院した。合併症は 83.3%の患者に認め、多種の合併症が自宅退院に影響を与えた。
集学的リハビリテーションプログラムは重症な骨盤輪骨折や骨盤骨折を含む多発外傷の高齢患者の転帰を改善させ、自宅退院を可能にするために有用であると考えられる。より包括的な知見を得るためには、大規模で焦点を絞った研究が必要である。この知見を得ることで臨床的意思決定をサポートし、長期的転帰を改善するために極めて重要である。

## Introduction

Pelvic fractures account for approximately 20% of blunt trauma injuries and 2–8% of all skeletal injuries[1] They can occur due to both high- and low-energy trauma and range in severity from mild to life-threatening[2-4].

Pelvic trauma, particularly from high-energy incidents, is often accompanied by significant comorbidities[5]. The occurrence of pelvic fractures, especially when combined with intra-abdominal injuries and intracranial hemorrhages, can result in mortality rates as high as 50%[6]. Managing these complications may require surgery and prolonged recovery periods, adding complexity to the treatment process[7]. Additionally, older patients tend to suffer from severe injuries and require longer recovery times because they often have a lower reserve capacity and pre-existing medical conditions. Pelvic ring fractures are considered one of the most serious traumas that significantly affect a patient's daily life. Even though patients survive, the recovery and rehabilitation processes are challenging compared to other trauma injuries. Therefore, rehabilitation services must prioritize a multidisciplinary approach to help patients improve their long-term quality of life and function, thereby facilitating their reintegration into society[8-12].

Moreover, patients in the intensive care unit (ICU) tend to lose muscle mass[13,14]. Early mobilization is necessary to prevent muscle loss during hospitalization and bed rest. Still,

106 the feasibility of rehabilitation is influenced by various factors, such as the patient's
107 general condition, complications, and stability of pelvic fixation, necessitating an
108 individualized approach for each patient. However, there are few reports on the current
109 state of rehabilitation and long-term outcomes of patients with severe pelvic ring fractures
110 caused by high-energy trauma. Therefore, this study aimed to investigate the
111 rehabilitation status and long-term outcomes of older patients with severe pelvic fractures.
112

113 **Materials and Methods**

114 ***Patient Cohort***

115 191 patients with pelvic fractures were admitted to Kyushu University Hospital between
116 April 2013 and April 2023. Of these, 39 patients that were over 65 years had pelvic
117 fractures due to high-energy trauma Patients were excluded from our study if they met
118 the following criteria: (1) patients with acetabular fractures; (2) patients with an injury
119 severity score (ISS) of 15 or less[15]; and (3) patients with a brain hernia or head injury of
120 AIS 5 or greater who were not eligible for rehabilitation. As shown in Fig. 1, 24 patients
121 were eligible for inclusion.
122 This retrospective study was approved by the Ethics Committee of Kyushu University
123 Hospital (23217-00). The informed consent was obtained in the form of opt-out. Those

who rejected were excluded.

As shown in Table 1, the mean age of the patients was 78.5 years old (range, 66–93 years), and the mean ISS was 27.9 (range, 16–48). Hemorrhagic shock occurred in 14 patients. Twenty-three patients required blood transfusion, and six required massive blood transfusion within 24 h. The mean transfusion volume was 12.4 units (range, 0-28) of red blood cells, 9 units (range, 0-32) of fresh frozen plasma, and 7.5 units (range, 0-80) of platelets. Twelve patients required transcatheter arterial embolization (TAE), and 12 required external fixation (EF).

The pelvic ring fractures were classified using the AO/OTA and Young-Burgess classifications, with the following distributions: A2.1:2, A2.2:2, B2.1:7, B2.2:4, B2.3:2, B3.2:2, C1.1:1, C1.3:3, C3.2:1, APC1:1, APC2:2, LC1:11, LC2:4, LC3:3, and VS:3 (Table 1).

Osteosynthesis was performed in 16 patients diagnosed with unstable fractures, while only one patient was treated with EF alone. The fixation technique was chosen by the surgeon according to each fracture type: ramus screws were used in nine patients, transiliac-transsacral or iliosacral screws were used in 12, trans-iliac rod fixation (TIRF)[16] was performed in eight patients, and plates were used in five patients. The mean follow-up duration after the fracture was 27 months (range, 3–120 months).

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144 ***Initial Medical Treatment and Operative Technique***

145 Initial trauma care was provided in accordance with the Japan Advanced Trauma
146 Evaluation and Care Resuscitation protocol[17,18]. EF was performed in patients who
147 presented with hemodynamic and/or mechanical instability due to multiple trauma and
148 pelvic fractures. Patients with extravasation confirmed on enhanced computed
149 tomography underwent TAE. Patients in unstable respiratory, circulatory, and conscious
150 states were admitted to the ICU for stabilization. After recovery, osteosynthesis was
151 attempted as soon as possible. The fixation method was also selected to allow early weight
152 bearing.

153

154 ***Rehabilitation Protocol and Follow-Up***

155 Our ICU rehabilitation protocol commences with an assessment of the patient's level of
156 consciousness, respiratory condition, and circulatory status. In cases of altered
157 consciousness, our medical team evaluates whether it stems from sedation, delirium or
158 dementia and makes necessary medication adjustments. If head trauma is suspected to
159 impact communication, we initiate bedside passive motor exercises to prevent joint

contractures. If the patient's respiratory status is not stable, monitor for tachypnea and oxygen saturation, and try to increase the level of bed rest. Ventilated patients receive careful oversight from nurses and specialist physical therapists, transitioning to sitting at the bedside or reclining wheelchair, with an eventual goal of progressing to standing training. Additionally, the level of rehabilitation should be adjusted while closely monitoring the minute volume and tidal volume of the ventilator. With regard to circulatory status, we assess the use of high volume catecholamines (e.g., noradrenaline at ≤0.1 gamma) and the need for continuous blood transfusions. If stable, we initiate rehabilitation with bedside sitting; if not, we limit activities to bedside passive motor exercises. Patients on extracorporeal membrane oxygenation or undergoing continuous renal replacement therapy also begin with bedside passive motor exercises. Following surgical completion and stabilization of the patient's overall condition, our rehabilitation protocol typically commences on the third postoperative day. This protocol includes advancing to wheelchair transfers, standing training, and weight-bearing exercises, decisions made through multidisciplinary discussions involving surgeons, nurses, psychiatrists, and physical therapists. Once sufficient fixation is achieved through osteosynthesis, weight-bearing limitations are not established. Patients requiring not weight bearing due to other limbs injury are preferentially trained using the limbs that

could perform weight-bearing. If the lower extremities cannot perform weight-bearing, toe touch exercises are permitted. Patients are discharged from the ICU upon stabilization of respiratory and circulatory status. Subsequently, as the patient's general condition improved and the need for multidisciplinary management decreased, the patient are transferred to a rehabilitation hospital, where rehabilitation become the mainstay of treatment.

The follow-up of the patients' conditions is conducted primarily at the rehabilitation hospital, with the primary surgeon following up through telephone calls and outpatient visits at the rehabilitation hospital.

**Results**

The median time to wheelchair transfer was 12 days (inter-quartile range (IQR): 7–16 days) after the injury, and the median time to wheelchair transfer postoperatively was 3 days (IQR: 2–12 days). One patient could not be transferred to a wheelchair because of severe head trauma and dementia, exhibiting risky behavior that made wheelchair transfer difficult. The median dates of training initiation in the standing position were 17 days (IQR: 7–40 days) after the operation and 7 days (IQR: 4-28 days) postoperatively. The median full weight bearing time was 41.5 days (IQR: 7.8–60.5 days), and postoperatively,

196 it was 28.5 days (IQR: 6–48 days) (Table 2).

197 The median length of ICU stay was 4.5 days (IQR: 3–11 days). The median length of
198 ventilation time was 0 days (IQR: 0–5 days). The median length of hospital stay was 28.5
199 days (IQR: 19.5–44.5 days). The median hospital stay was 142 days (IQR: 108–193 days).
200 Fifteen patients were eventually discharged home, five were transferred to a nursing home,
201 and four died in the hospital. The causes of death were as followings: two were due to
202 pneumonia, one was due to intestinal necrosis, and one was due to the worsening of pre-
203 existing cancer. Finally, nine patients could walk without any supportive apparatus (Table
204 3). Four patients needed a cane, and one still needed a walker. The other four patients still
205 needed wheelchairs. Unfortunately, two patients had to be bedridden.
206 Complications occurred in 20 patients (83 %) during the study period. Five patients had
207 deep vein thrombosis; five had aspiration pneumonia; three had urinary tract infections;
208 two had ileus; two had sacral bedsores; two had non-union (ramus and ankle); and one
209 each had pin site infection, acute respiratory distress syndrome, fat embolism, and
210 cholangitis.

211

212 **Discussion**

213 This study investigated the weight-bearing times, discharge rates, and complications in

older patients with severe polytrauma and pelvic ring fractures at a single facility. Our findings revealed that 79.2% of the patients achieved full weight-bearing, with a median time of 41.5 days, and the median length of hospital stay was 142 days. Notably, 58.3% of the patients were discharged to their homes. Various factors were examined to identify what made home discharge possible. Still, no significant differences were found in factors such as ISS, presence of head trauma, presence of hemorrhagic shock, presence of lower extremity trauma other than pelvic ring fracture, date of start of wheelchair transfer, date of start of full weight bearing, and the duration of total hospitalization. However, these results may have been influenced by the small number of patients, the heterogeneous nature of severe polytrauma, including pelvic ring fractures, and the impact of individual patient and environmental factors, representing a limitation in our study of patients with multiple traumatic injuries.

Previous studies have reported return-to-work rates for young patients with unstable pelvic fractures, ranging from 54% to 84%[19-24]. Gabbe et al. reported that 77% of patients with severe pelvic ring fractures could return to work. The significant factors for return to work were low ISS and time since injury[25]. However, that study was based on data from a group of patients, 65% of whom were under 50 years of age. To date, there have been no reports on critically ill older patients with pelvic ring fractures. Therefore, this is

the first report to present real data regarding these patients. In this study, the rate of returning home was higher than expected, even in the severe group. We can probably compare the rate of return home in this study to the rate of return to work in previous studies because patients older than 65 years have most likely retired from their jobs.

Regarding weight-bearing time, Rojas et al. reported average periods of 105.9 and 71.2 days for independent ambulation in patients with unstable and stable pelvic ring fractures, respectively, with an average age of 45.5 years[26]. Although our study focused on the time when patients started full weight-bearing, the time when independent walking became possible was not recorded because of the transfer of patients to rehabilitation hospitals. Despite this limitation, considering the period from full weight-bearing to discharge, the patients may have achieved a stable, independent gait before discharge, and the time to achieve walking independence was comparable.

There is no ideal rehabilitation protocol for multiple trauma patients with pelvic ring fractures. These complex traumatic injuries vary greatly, and some patients may exhibit unstable consciousness, respiratory issues, and circulatory concerns, making them reluctant to undergo aggressive rehabilitation. In reports on early rehabilitation interventions for ventilator-dependent patients admitted to the ICU, there is evidence both in favor and against interrupting sedation and providing rehabilitation while the patient is

on a ventilator. One study suggests that such interventions can reduce delirium, shorten hospital stays, and improve functional outcomes[27]. However, there is also report indicating potential risks, including adverse events such as arrhythmias and hypotension[28]. Therefore, it is essential to develop a customized rehabilitation program tailored to each patient's specific condition. Considering that elderly patients often have limited reserve capacity, our approach aims to facilitate early hospital discharge while prioritizing their overall well-being.

The individualized, tailor-made medical care required to treat polytrauma is best achieved through a multidisciplinary rehabilitation program. At our facility, this approach is adopted by various specialists collaborating to deliver comprehensive care to patients. These include emergency physicians, intensivists, orthopedic surgeons, trauma surgeons, cerebral cardiologists, cardiologists, anesthesiologists, and cardiac surgeons. Once the trauma is localized, patients are referred to specialists for targeted interventions. In the ICU, a multidisciplinary rehabilitation program involving psychiatrists, dentists, nurses, physical therapists, occupational therapists, nutritionists, and social workers is employed to address factors hindering early mobilization and expedite bed release. Although the cost-effectiveness of such multidisciplinary rehabilitation programs in multiple traumas is yet to be established[29], they have shown promise in shortening treatment time and

268 improving patient function and quality of life,[9,30] particularly in older patients with
269 polytrauma and pelvic ring fractures.
270 This information is crucial for guiding clinical decision-making and optimizing long-term
271 outcomes in this vulnerable patient population. Despite the severity and frailty, higher
272 rates of full weight-bearing and home discharge were observed. These results highlighted
273 the importance of comprehensive rehabilitation and tailored medical care.
274 In conclusions, this study showed the weight-bearing times, discharge rates, and
275 complications in older patients with severe polytrauma and pelvic ring fractures.
276 Individualized multidisciplinary rehabilitation programs are promising for improving
277 patient outcomes and facilitating recovery.
278

279 ***Consent for publication***

280 Not applicable.

281

282 ***Availability of Data and Materials***

283 The datasets generated and/or analyzed in the current study are available from the

284 corresponding author upon reasonable request.

285

286 ***Conflict of Interest***

287 All authors declare that they have no conflict of interest.

288

289 ***Author Contributions***

290 MK, YH, NT, CM and OK contributed to the data collection. MK contributed to database

291 creation. MK contributed to the pelvic surgery and treatment decisions. AT and CM

292 contributed to analyzed data. All authorscontributed to the multidisciplinary treatment

293 and approved the final version of the manuscript.

294

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297

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411

412 **Figure legends**

413 Fig. 1. Participant flow diagram.

414 ICU, intensive care unit; ISS, injury severity score.

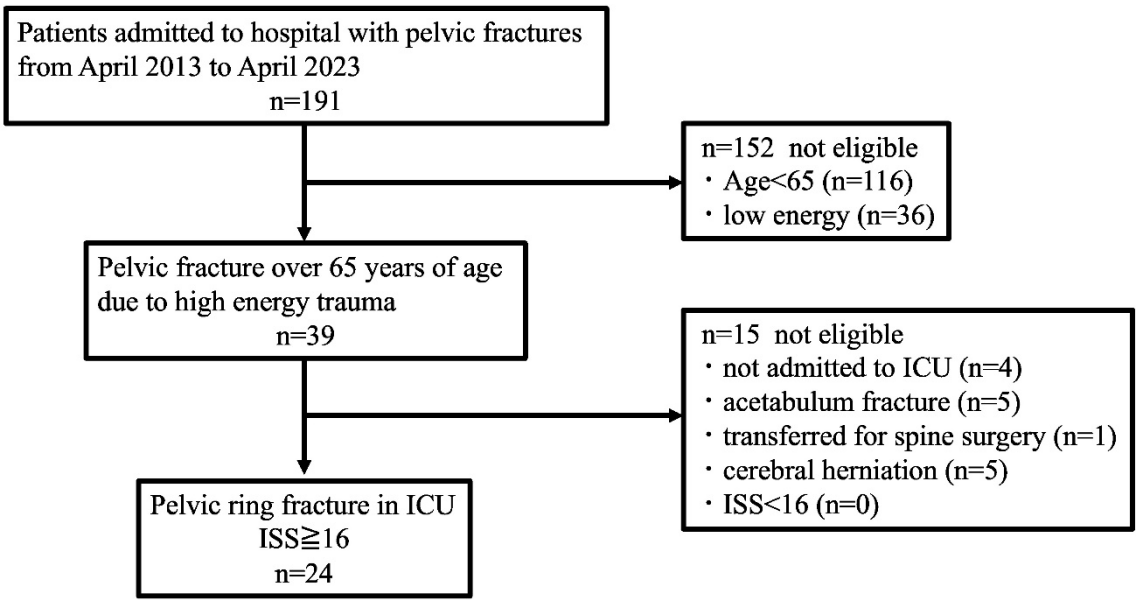


Figure 1 Participant flow diagram.

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**Table 1. Characteristics of the patients with pelvic ring fractures due to high energy trauma treated in ICU**

| Factor | Patients (n=24) |
|---|---|
| Age, (years) (range) | 78.5 (66–93) |
| Gender (Female/Male) | 12/12 |
| Injury severity score (range) | 27.9 (16–49) |
| Hemorrhagic shock (%) | 14 (58) |
| Massive transfusion (MAP >20 U) | 6 |
| Transarterial embolization | 12 |
| External fixation | 12 |
| AO/OTA, No. (%) | |
| A2.1 | 2 (8.3) |
| A2.2 | 2 (8.3) |
| B2.1 | 7 (29.2) |
| B2.2 | 4 (16.7) |
| B2.3 | 2 (8.3) |
| B3.2 | 2 (8.3) |
| C1.1 | 1 (4.2) |

| | |
|---|---|
| C1.3 | 3 (12.5) |
| C3.2 | 1 (4.2) |
| Younge | |
| -Burgess, No. (%) | |
| APC1 | 1 (4.2) |
| APC2 | 2 (8.3) |
| LC1 | 11 (45.8) |
| LC2 | 4 (16.7) |
| LC3 | 3 (12.5) |
| VS | 3 (12.5) |
| Osteosynthesis, No. (%) | 16 (67) |
| Ramus Screw | 9 (37.5) |
| TIRF | 8 (33.3) |
| Conservative | 7 (29.2) |
| TITS Screw | 7 (29.2) |
| Plate | 7 (29.2) |
| IS screw | 5 (20.8) |
| External Fixation | 3 (12.5) |

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**Table 2**

| Factor | Duration |
|---|---|
| Wheelchair transfer, days (IQR) | 12 (7–16) |
| Standing position, days (IQR) | 17 (7–40) |
| Full weight-bearing walk, days (IQR) | 42±33 |
| ICU stay, days (IQR) | 4.5 (3–11) |
| Total hospital stay, days (IQR) | 142 (108–193) |

**Table 3. Data regarding patient prognosis**

| Factor | Number of patients |
|---|---|
| Survival (Alive/Dead) | 20/4 |
| Walking ability | Total (n=20) |
| Walking alone | 9(45%) |
| Use of a walker | 1 |
| Use of a cane | 4 |
| Wheel chair | 4 |
| Bedridden | 2 |
| Discharge location | |
| Home | 15 |
| Nursing home | 5 |

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