Changes in Epidemiology and Treatment of Pelvic Ring Fractures in Germany: An Analysis on Data of German Pelvic Multicenter Study Groups I and III (DGU/AO)

Změny v epidemiologii a léčení zlomenin pánevního kruhu v Německu: Analýza vypracovaná na podkladě údajů skupin I. a III. Německé multicentrické pánevní studie (DGU/AO)

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SUMMARY

The diagnosis and treatment of pelvic ring injuries is demanding. Therefore, standardized classifications characterizing the stability and severity of pelvic ring fractures are essential to define clear algorisms for the treatment of these injuries. The first part of this article provides an overview of the etiology and classification of pelvic ring injuries. We recommend the AO classification to assess the stability of pelvic ring fractures. This classification includes 3 types of pelvic ring fractures: stable fractures (type A), fractures with only rotational instability (type B), and fractures with complete (rotational and translational) instability. To describe the severity of the injury, pelvic ring fractures can be classified as plain pelvic fractures, which include fractures with osteoligamentous instability, but without significant concomitant injuries to the soft tissue, versus complex pelvic fractures, which are combined with severe peripelvic soft tissue lesions. While plain pelvic fractures allow thorough clinical and radiological diagnostics, complex pelvic traumata represent a life threatening situation for the patient, which needs immediate emergency measures.

In the second part of the this review we present current data of the German Pelvic Multicenter Study III (DGU/AO) on the epidemiology and treatment of pelvic ring injuries deriving from a study population of more than 3000 patients. In addition, we compare the present data with those of the German Pelvic Multicenter Study I and highlight changes in the epidemiology and treatment of pelvic ring fractures during the past decades. Taken together, we could observe an increasing number of elderly patients sustaining pelvic ring fractures. Regarding the treatment of pelvic ring fractures we found a rising use of external fixators and SI screws, while the number of laparotomies has markedly decreased.

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INTRODUCTION

The pelvic ring consists of the innominate bones (pubis, ilium, and ischium) and the sacrum. Both hemipelvises are connected by tense joints (sacra-iliac joints and symphysis pubis) . The strongest structures are located dorsally and transmit the essential part of impact from the lower extremities to the trunk (about 70%). While isolated anterior fractures have no relevant effect on the stability of the pelvic ring, a complete rupture of the dorsal ligaments is always related to instability of the pelvis. The direction of impact and the magnitude of transmitted energy determine the anatomic localization, the character, and thus the degree of instability of a pelvic ring injury (21).

The stability of the pelvic ring depends on the strength of the symphyseal, sacra-iliac, sacra-tuberous, and sacra-spinous ligaments. Fractures that result in separation of the symphysis pubis and sacra-iliac joints are accordingly associated with a rupture of those ligaments. Besides, the ligaments supply a stable compartment for the vascular, neural, and visceral structures of the pelvis. This critical role of the ligaments explains the increased morbidity and mortality related to pelvic injuries with ligamentous disruption (21).

The iliac artery and vein are located ventrally in direct contact to the SI joints. In accordance, disruption of the SI joints increases the risk of hemorrhage resulting from vascular injury of the internal iliac vessels. This close anatomic relation of the viscera to the pelvic ring explains the great risk of visceral injuries associated with pelvic fractures (3, 21).

The diagnosis and treatment of pelvic injuries is challenging and requires the care of an experienced trauma team. While complex pelvic traumata represent a life threatening situation for the patient, which needs immediate emergency measures, plain pelvic fractures allow thorough clinical and radiological diagnostics, including computerized tomography. Standardized classifications characterizing the severity and stability of the pelvic fracture help in defining clear algorisms for further treatment. Surgical treatment modalities include a wide spectrum of different osteosynthesis techniques in addition to emergency procedures dealing with control of mass bleeding as well as treatment of neurovascular and visceral injuries.

This article reviews the etiology and classification of pelvic ring injuries. In addition, data of the German Pelvic Multicenter Study Group 1 and 3 of the German trauma association (DGU) and the Association for the Study of Internal Fixation (AO) provide an overview of the epidemiology and contemporary treatment concepts of pelvic ring injuries.

Etiology and classification

Fractures of the pelvic ring are relatively rare with an incidence of 3 to 5% of all fractures. In contrast to most fractures of other body regions, however, pelvic ring fractures are associated with a high mortality of up to 20% (13).

Pelvic fractures in young patients are mostly caused by high energy trauma (e.g. traffic accidents, falls from greater altitude). More than 80% of those patients have concomitant injuries of another body region. Because of the huge forces necessary to generate a pelvic fracture, the mortality in these patients is proportionately high, particularly due to associated head, thoracic or abdominal injuries. Thus, data of the German pelvic study group III have shown a mortality rate of 18% in those patients with complex pelvic fractures. Besides, lifelong invalidity may result in many cases (3, 13).

In the elderly, also low energy traumas, i.e. domestic falls, may lead to pelvic injuries (mainly to fractures of the anterior pelvic ring). Women around the 7th life decade compose this second peak of incidence (2). Data of the German Pelvic Multicenter Study III have demonstrated that more than 50% of all anterior pelvic ring fractures occur in women older than 65 years of age. Special regard has to be taken to pelvic injuries in children as the impact of the injury is often under-estimated due to the higher elasticity of their bone (8).

To assess the severity of the injury the following definitions are used to classify pelvic fractures:

– *Plain pelvic fracture:* Pelvic fracture with osteoligamentous instability, but without concomitant injuries to the soft tissue. This group of pelvic fractures covers about 90% of all pelvic fractures (13).
– *Complex pelvic fracture:* Pelvic fracture combined with soft tissue lesions in the pelvic region. These may include visceral, urogenital, and neurovascular injuries, as well as extensive skin injury. Complex pelvic traumata include only about 10% of all pelvic fractures, but are associated with a mortality of around 20% (1).
– *Pelvic fracture with hemodynamic instability:* Unstable pelvic fracture combined with hemodynamic instability related to the pelvic injury. The term "hemodynamic instability" is characterized by an estimated overall blood loss of more than 2000 ml (hemorrhagic shock class III and IV). Because of the difficulty of estimating the blood loss in an emergency situation, one takes account of a systolic blood pressure of <70 mm Hg and a hemoglobin concentration of <8 g/dL on admission of the patient (10).
– *Traumatic hemipelvectomy*: Subtotal dislocation of one hemipelvis with complete neurovascular dissociation of the hemipelvis (12).

To characterize the stability of the pelvic ring, we recommend the AO classification that describes 3 types of injuries:

– *Type A:* Stable injuries of the pelvic ring. The pelvic ring is not displaced and remains intact. Type A injuries of the pelvic ring include fractures of the pubis and ischium, fractures of the iliac crest, avulsion fractures i.e. of the anterior superior iliac spine, as well as transverse fractures of the sacrum under the line of the S1 body (13).
– *Type B:* Rotationally unstable, but vertically stable injuries of the anterior and posterior pelvic ring. The stability of the posterior ring in type B injuries is par-

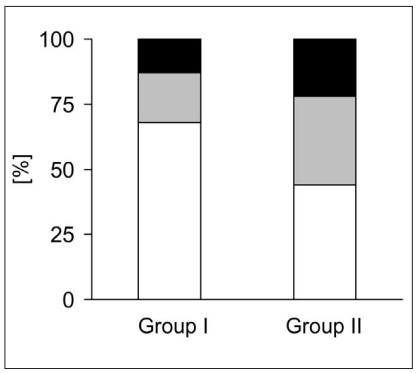

Figure 1. Fractions of pelvic ring fractures type A (white columns), B (grey columns) and C (black columns) in the pelvic study groups I and II.

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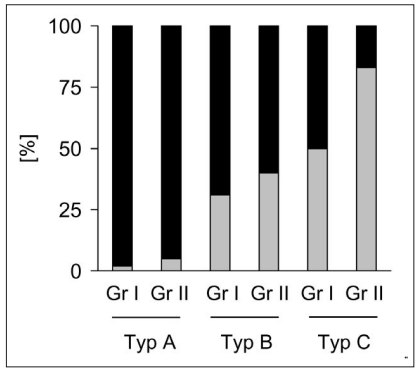
Figure 2. Fractions of pelvic ring fractures were treated operatively (grey columns) and non operatively (black columns) in the pelvic study groups I (Gr I) and II (Gr II). ▶



tially maintained, as the strong posterior ligaments remain intact (13).

– *Type C:* Translationally unstable injuries with complete disruption of the posterior arch, the pelvic floor, and usually the anterior arch (13).

Data of the German Pelvic Multicenter Study Groups I and III (DGU/AO)

Epidemiology

In 1991, the German Pelvic Multicenter Study Group I (DGU/AO) started a prospective multicenter study including ten major trauma centers. During the following time period until 1993, 1722 cases (55% males, 45% females) of pelvic ring and acetabular fractures were collected, which included 1076 cases of isolated pelvic ring fractures. Starting in 2005, the German Pelvic Multicenter Study Group III analyzed additional 4533 pa-tients with pelvic ring and acetabular fractures. Data collection in this study group comprised a total of 3019 patients sustaining pelvic ring fractures between 2005 and 2009. In contrast to the pelvic study group I, the number of female patients with pelvic fractures (58%) in the pelvic study group III was higher than that of males (42%). The mean age of patients was 47 years in the pelvic study group I and 58 years in the pelvic study group III.

In the pelvic study group I, the number of isolated pelvic ring fractures type A was n=728 (68%), that of type B n=205 (19%), and that of type C n=143 (13%). In the pelvic study group III, isolated pelvic ring fractures type A included n=1326 (44%), type B n=1013 (34%), and type C n=680 (22%) (Figure 1).

Treatment

In the pelvic study group I, only 2% of type A fractures were treated operatively. The number of type A fractures, which were treated operatively in the pelvic study group III, was 5% (Figure 2). Both in the pelvic study group I and III, the major fraction of surgical procedures in type A fractures consisted of a stabilization of the ilium by screws and/or plates.

The number of type B fractures, which were treated operatively was 31% in the pelvic study group I and 40% in the pelvic study group III (Figure 2). In the majority of type B fractures, the anterior pelvic ring was stabilized definitively by the use of an external fixator (pelvic study group I: 25%; pelvic study group III: 38%) or plating of the symphysis (pelvic study group I: 78%; pelvic study group III: 34%). In the pelvic study group I, the posterior pelvic ring was stabilized in only two cases (SI screws and plating), while it was stabilized in 177 cases (52%) of the pelvic study group III. In the pelvic study group III, SI screws (21%) or plates (25%) were used in the majority of these cases.

In contrast to type A and B fractures, the major fraction of type C fractures was treated operatively (pelvic study group I: 50%; pelvic study group III: 83%) (Figure 2). As in type B fractures, also in type C fractures the anterior pelvic ring was stabilized predominantly by an external fixator (pelvic study group I: 25%; pelvic study group III: 35%) or plating of the symphysis (pelvic study group I: 21%; pelvic study group III: 20%). In the pelvic study group I, the posterior ring was fixed in 42% of cases by plates and in 6% of cases by SI screws, while in the pelvic study group III plates were used in 34% of cases and SI screws in 37% of cases.

In the pelvic study group I, emergency surgery was necessary in n=165 out of n=1722 patients (10%). Pelvic C clamp was applied in n=19 out of these n=165 patients (12%). In n=48 patients an external fixator was used for the stabilization of the pelvic ring (29%). Internal fixation was performed in n=42 cases (25%). Pelvic packing was applied in n=19 patients (12%), while laparotomy was performed in n=94 cases (57). In the pelvic study group III, n=462 out of n=4533 patients were treated by emergency surgery (10%). These measures included external stabilization by the use of a fixator (n=317; 69%) or a pelvic C-clamp (n=74; 16%) and primary internal fixation (n=81; 18%). Additionally, pelvic packing was applied in n=54 cases (12%). A laparotomy was performed in only n=15 cases (3%).

Summary and recommendations

Pelvic injuries, particularly when combined with multiple trauma, still represent a potentially life-threatening situation. To ensure the survival of the patient, defined treatment algorisms based on standardized classifications are required. The AO classification is recommended to assess the stability of a pelvic fracture and serves as an important tool for further decisions on surgery. The AO classification includes 3 types of pelvic fractures: stable pelvic fractures (type A), pelvic fractures with

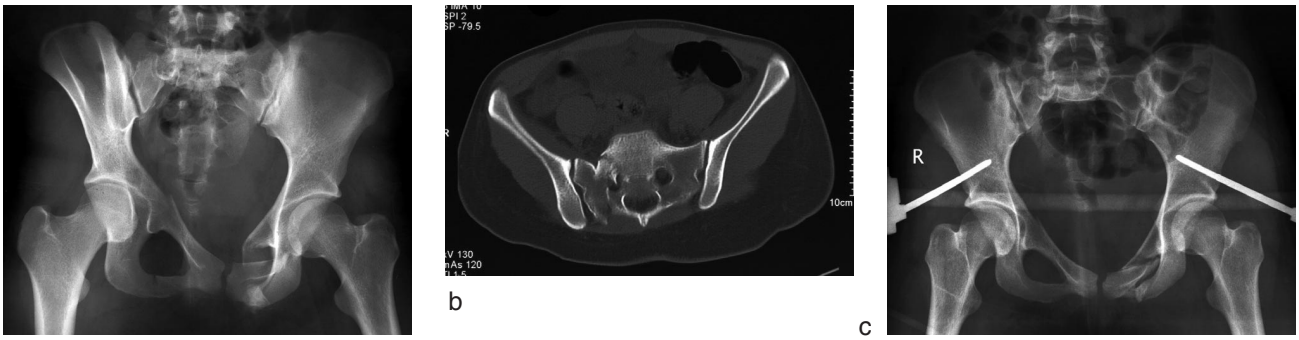
a
b c d

Fig. 3a–d. 75 years old patient. Pelvic ring injury type B1 with disruption of the symphysis (a); 3 months follow up after plating of the symphysis pubis. The plate is placed on the apical aspect of the symphysis pubis and fixed by inserting the screws in cranio-caudal direction. A.p. (b), inlet (c) and outlet (d) view.

only rotational instability (type B), and pelvic fractures with complete (rotational and translational) instability. Instability of a pelvic fracture represents the primary indication for surgery. In accordance, type C fractures must be always considered for surgical treatment, while the majority of type A fractures are treated non-surgically. Only in a very few cases (e.g. avulsion fractures) surgery has to be applied in type A fractures. Type B fractures can be treated non-operatively, too. If dislocation of the pelvic ring occurs, however, the anterior arch of the pelvic ring has to be fixed either by an external fixator or by plating of the pubic symphysis (diastasis of the symphysis pubis >2.0cm) (Figure 3).

Comparing data of the pelvic study groups I and III, the fraction of female patients increased during the past two decades. One explanation for this changing gender distribution might be that the number of geriatric women sustaining pelvic ring fractured is rising (7). Regarding the type of pelvic ring fractures, we observed an increase of type B and C fractures, while the fraction of type A fractures decreased. Because of an improvement of imaging associated with a higher rate of CT diagnostics, the number of misinterpretation in the classification of pelvic ring fractures decreased (20). Therefore, the number of type B fractures, which were incorrectly classified as type A fractures as well as the number of type C fractures, which were incorrectly classified as type B fractures, obviously could be reduced.

Fig. 4a–c. 18 years old patient with pelvic ring injury type C (right transforaminal right and transpubic fractures) (a); axial section of the CT-Scan showing a bone fragment in the S1 foramen (b); primary stabilization of the anterior pelvic ring with an supraacetabular external fixator (c).



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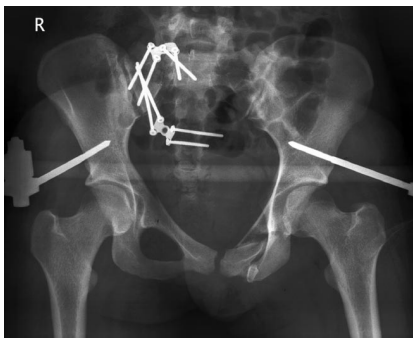

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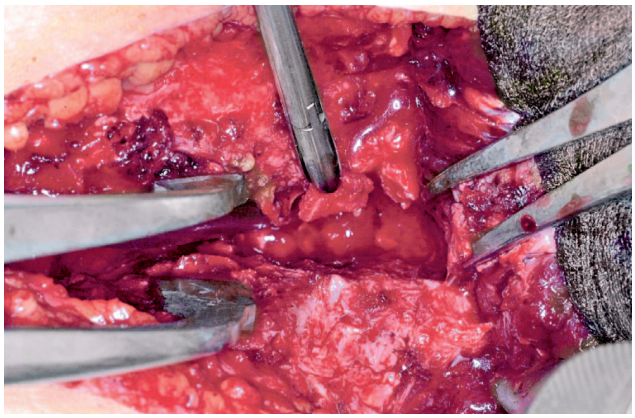

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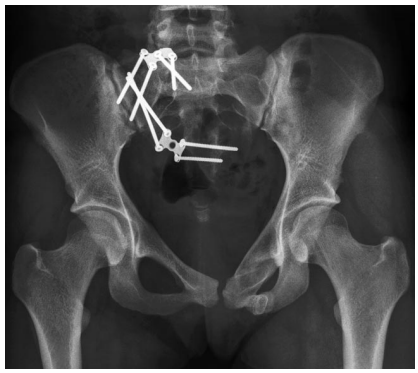

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Fig. 4d–f. Open reduction and internal fixation of the posterior ring 1 week after trauma (d); surgical removel of the fragment within the S1 foramen (e); follow up 1 year after surgery (f).

Of interest, a higher number of pelvic ring fractures (particularly type B and C fractures) was treated operatively in the pelvic study group III when compared to the pelvic study group I. In the literature, an increase of type B fractures with internal rotation (type B2) is reported, especially in the elderly. In these cases, the external stabilization with a supraacetabular fixator provides a suitable treatment option (20). In accordance, data of the pelvic study group III show an increased use of external fixators for the treatment of type B fractures. Our own experience shows that the application of an external fixation provides an effective and low invasive procedure for the stabilization of the anterior pelvic ring both in young patients and in the elderly.

While stabilization of the anterior arch is sufficient for type B fractures, combined posterior and anterior stabilization is necessary for treatment of type C fractures (Figure 4). In these cases, the posterior arch has to be fixed first, facilitating the subsequent reduction of the anterior arch. A major dislocation of the pelvic ring requires an open reduction and internal fixation of the posterior arch by a reconstruction plate or SI screws. Type C fractures, which do not show significant dislocation or which can be reduced closely, can also be fixed percutaneously by SI screws (Figure 5) . Comparing data of the pelvic study groups I and III, we observed an increasing application of SI screws. One explanation for the rising use of SI screws is the continuously improving quality of intraoperative imaging, which allows a standardized and safe closed positioning of the screws. In addition the surgical experience in this procedure increased during the past decade (15–17). Our own experience shows that the percutanenous pelvic ring fixation by SI screws implicates a very low complication rate (e.g. operative blood loss and wound healing disturbances) and is associated with a short operation time (19).

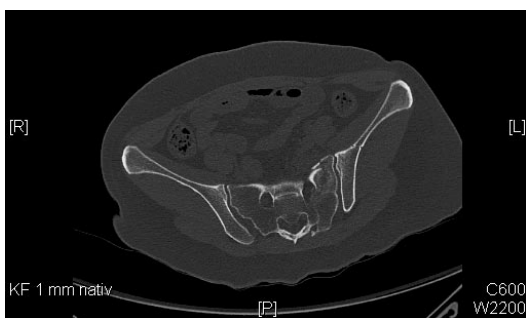
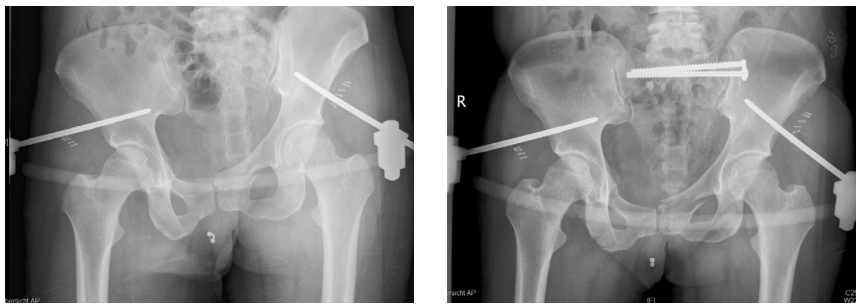


Fig. 5a. 32 years old patient with pelvic ring injury type C (left transforaminal right and transpubic fractures). Axial section of the CT-Scan.



b c

Fig. 5b–c. Primary stabilization of the pelvic ring with an supraacetabular external fixator (b); closed reduction and internal fixationw with two SI-screws of the posterior ring 1 week after trauma (c).

The fraction of emergency surgeries for pelvic ring fractures has not changed during the observation times of the pelvic study groups I and III. However, the application of the external fixator and the pelvic C clamp markedly increased and has been established as emergency measurement for the mechanical stabilization of pelvic ring fractures. According to literature, the application of these stabilization methods is an effective, safe and fast procedure (14). The most obvious change in the emergency treatment of complex pelvic ring fractures is the nearly complete disappearance of laparotomies in the pelvic study group III. Retrospectively this development is not surprising, as we have learned that in most cases the origin of severe bleeding associated with pelvic ring fractures is not the abdomen but the presacral venous plexus in the lesser pelvis.

For the treatment of complex pelvic ring injuries in hemodynamically unstable patients, we recommend the following procedure: The pelvic C-clamp by GANZ, which consists of two pins connected by a compressible C-arm (6), should be applied immediately on patients with an unstable type C fracture associated with hemodynamic instability. Contraindications for the application of the C-clamp are transiliacal injuries and transiliacal luxation fractures of the SI-joint (11). The application of the pelvic C-clamp allows an immediate and effective stabilization of the posterior pelvic ring already in the resuscitation area, and can be used in elderly patients, too (9, 14, 18). If hemodynamic stabilization is achieved by this measure, time for further diagnostics and therapy options is attained (10). If no hemodynamic stabilization can be achieved after 15 to 20min (non-responder), further measures must be assumed. As in 80 to 90% of all cases massive bleedings derive from the paravesical and presacral venous plexus or from cancellous bone of the fracture planes, the implementation of pelvic tamponade for mechanical hemostasis has been proven to be one of the most effective methods to control hemorrhage (5). Only in a very few cases of arterial bleeding, additional arterial embolisation is required (22). The immediate application of these procedures is essential, because the wastage of hemostatic factors and further cooling of the patient leads to a worsening of hemostatic conditions (3).

Acknowledgement

We greatly appreciate Sbaine Wickert for her excellent technical assistance.

The authors wish to thank the members of the German Pelvic Multicenter Study Groups I and III (http://www.dgu-online.de/de/dgu/gruppierungen/ /ags/becken.jsp) for the documentation of their patients.

Group I: Zentralklinikum Augsburg, Freie Universität Berlin Klinikum Benjamin Franklin, Klinikum Braunschweig, Allgemeines Krankenhaus Celle, Universitätsklinik Freiburg, Medizinische Hochschule Hannover, Universitätsklinik Kiel, Universitätsklinik Marburg, Universitätsklinikum München (Innenstadt), BG-Unfallklinik Tübingen.

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