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The Risk of Erectile Dysfunction Following Pelvic Angiographic Embolization in Pelvic Fracture Patients: A Nationwide Population-Based Cohort Study in Taiwan

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Abstract

Background Pelvic fracture with hypovolemic shock is a known crucial injury in trauma patients. Pelvic fracture with vessel injury often leads to hemodynamic complications; in a trauma scenario, evidence of other systems being affected is often absent. Bleeding cessation and resuscitation are important for these types of trauma patients. For this purpose, pelvic angiographic embolization is frequently used. Multiple studies have reported that angiographic embolization may cause erectile dysfunction (ED) in hemodynamically stable patients with pelvic fracture. However, no study has evaluated a large patient cohort with a long-term follow-up. We hypothesized that angiographic embolization to control bleeding may compromise blood supply to the genitourinary organs or cause secondary neurogenic injury that increases the risk of ED. Our goal was to evaluate the risk of ED following pelvic fractures in male patients treated with pelvic angiographic embolization.

Methods We used data from the National Health Insurance Research Database (NHIRD) from 1997 to 2010 provided by the Bureau of National Health Insurance of the Department of Health in Taiwan. We collected disease histories from inpatient files. The disease diagnoses were based on the International Classification of Diseases (ICD), Ninth Revision, Clinical Modification. These data were all deidentified, and we did not contact the patients. As such, informed consent was not needed.

Results Eighty-five and 82,802 patients were included in the case and control cohorts, respectively. All patients were aged 15–45, and the proportion of pelvic fracture locations was equal between the groups. After investigating the causes of ED among male patients aged 15–45 with pelvic fractures using logistic regression analysis in a generalized estimating equations model and after adjusting for the influence of confounders, we found that these patients had high risks (odds ratio (OR): 32.637; 95% confidence interval: 14.137–75.346; $P < 0.001$) of developing ED post-angiographic embolization.

Conclusions Male patients in Taiwan with pelvic fractures who undergo angiographic embolization to control bleeding have a higher risk of ED than those who do not undergo the procedure. Physicians should practice caution and inform patients of this connection before the procedure.

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List of abbreviations

NHIRD	National Health Insurance Research Database
ICD	International Classification of Diseases
OR	odds ratio
ED	erectile dysfunction
NHI	National Health Insurance
NHRI	National Health Research Institutes
LHID	Longitudinal Health Insurance Database
ICD-9-CM	International Classification of Diseases, Ninth Revision, Clinical Modification
IIEF	International Index of Erectile Function
NPT	Nocturnal Penile Tumescence
GEE	Generalized Estimating Equations
CIs	confidence intervals
SAS	Statistical Analysis System
ISS	Injury Severity Score
REBOA	Resuscitative Endovascular Balloon Occlusion of the Aorta

Introduction

Pelvic ring fractures constitute 3–8% of all fractures in the skeletal system and are generally associated with high-energy trauma [1–3]. The most common mechanisms of pelvic injury are motor vehicle collisions (57%), pedestrians being hit by a car (18%), motorcycle crashes (9%), falling from heights (9%), and crushing injuries (5%) [1]. The urogenital system (bladder, urethra, vagina, uterus, and prostate) and lumbar-sacral plexuses are often concomitantly damaged because of their proximity to the bony pelvis [4, 5]. Urethral injury is a major risk factor for erectile dysfunction (ED) after pelvic fracture. Forty-two percent of pelvic fracture urethral injury patients have ED, compared with just 5% of pelvic fracture patients without urethral injury [6]. The incidence of ED is 20–84% in patients with urethral injury secondary to perineal trauma or pelvic fractures [7].

Within the last decade, angiographic embolization has been used with increasing frequency as an alternative to surgery to control post-traumatic intraperitoneal and retroperitoneal bleeding. Pelvic angiographic embolization is an effective procedure to stop arterial bleeding in which intra-arterial catheters are placed to selectively insert thrombotic agents into the injured branches of the internal iliac arteries.

Several complications occur after pelvic fracture, and ED is a common sequela with an incidence of 19–72% (mean: 45%) [5, 7]. ED after pelvic injury is known to be a combination of neurogenic, vascular, corporal, and psychogenic injuries [8]. ED is common among patients with urethral injury and associated vessel injuries due to pelvic fracture. However, systematic research concerning angiographic embolization for controlling bleeding in patients with pelvic fracture and the subsequent occurrence of ED is scarce. We developed a hypothesis that angiographic embolization to control bleeding may compromise blood supply to the genitourinary organs or cause secondary neurogenic injury, thus increasing the risk of ED. With this in mind, we designed a large-scale, nationwide, population-based, retrospective case control study using data from the National Health Insurance Research Database (NHIRD) in Taiwan to clarify the relationship between angiographic embolization for pelvic fractures in male patients and the risk of ED.

Methods

Ethical considerations

Our study was approved by the Institutional Review Board II of the Tri-Service General Hospital, National Defense Medical Center (approval number: 1-105-05-050). The study protocol was conducted following the ethical principles of the Helsinki Declaration of 1975, as revised in 1983.

Data sources

In 1996, Taiwan began its National Health Insurance (NHI) program, a single-payer, universal insurance plan with 97% coverage for clinics and hospitals. In 1998, almost 99% of

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the people in Taiwan were covered by the NHI program [8]. The NHI program created the NHIRD for researchers in Taiwan, which has been widely applied in epidemiologic and clinical studies [9–11]. The NHIRD includes annual registration files and original claims data for reimbursement and is managed by the National Health Research Institutes (NHRI). To protect patient privacy, all personal identification information is encrypted and unavailable before the data are released for research purposes. We used data from 1997 and 2010 from the NHIRD provided by the Bureau of National Health Insurance of the Department of Health in Taiwan.

We also collected data on disease histories from the Longitudinal Health Insurance Database (LHID), which is a sub-dataset of the NHIRD. The LHID randomly selected one million individuals who were insured between 1997 and 2010. The distribution of sex and age was similar between the LHID and NHIRD populations. The NHRI created a scrambled, anonymous identification number for each patient to combine each individual's information, including sex, birth date, and registry of medical services. The disease diagnoses were based on the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM).

Study population

We enrolled Taiwanese outpatients or inpatients with a diagnosis of pelvic fracture (ICD-9-CM: 808) between 2000 and 2010. We excluded patients aged <15 or > 45 years and those who had undergone operations for the genital organs or accessory organs previously (ICD-9-CM: OP60.3-60.6 and OP60.8-OP60.9), those with other congenital or acquired disorders near the genital organs (ICD-9-CM: 752.6, 187, 233.5, 607, or 878.0–878.1), and those who had undergone radiotherapy (ICD-9-CM: V580) or chemotherapy (ICD-9-CM: V58.11). Two genitourinary specialists designed the inclusion and exclusion criteria. They also helped to check disease codes by reviewing the study cohort database. International Index of Erectile Function (IIEF) criteria test [12, 13], nocturnal penile tumescence (NPT) test, duplex ultrasonography and cavernosography, and neurophysiological test [14] results were not available.

The index date of the study group was set as the pelvic angiographic embolization date, and the index date of the control group was set as the date on which ED was diagnosed. A total of 82,802 patients were included. Patients with pelvic fracture who were treated with angiographic embolization (ICD-9-CM: 444.81 and 448.9) (n = 85) were identified and classified as the case cohort. The control cohort consisted of pelvic fracture patients who did not undergo angiographic embolization (n = 82,717). The

follow-up period was terminated when ED was diagnosed (ICD-9-CM: 607.84), when the patient withdrew from the insurance program, or on December 31, 2010 (Fig. 1).

We evaluated the patients based on age (15–35 and 36–45 years); locations of pelvic fracture (acetabulum [ICD-9-CM: 808.0 and 808.1], pubis [ICD-9-CM: 808.2 and 808.3], and others [ICD-9-CM: 808, 808.4, 808.5, 808.8, and 808.9]); and possible confounders such as hyperplasia of the prostate (ICD-9-CM: 600), hypertension (ICD-9-CM: 401-5), diabetes mellitus (ICD-9-CM: 250), hyperglyceridemia (ICD-9-CM: 275.41), hypercholesterolemia (ICD-9-CM: 272.4), coronary artery disease (ICD-9-CM: 410-414), subsequent surgeries, Injury Severity Score ([ISS], ICD-9-CM: 959.99) and urethral injury (ICD-9-CM: 867.09-867.1, 598.2, 598.8-598.9).

Statistical analysis

To demonstrate the differences between the case and control cohorts, the count and percentages for category variables (locations of the pelvic fracture, age groups, hyperplasia of the prostate, hypertension, diabetes mellitus, hyperglyceridemia, hypercholesterolemia, coronary artery disease, subsequent surgeries, ISS and urethral injury) were calculated. The Chi-square test or Fisher's exact test was used for categorical variables to statistically examine the differences between the two cohorts. The cumulative risk of ED and the demographic- and comorbidity-specific ED incidences for the case and control cohorts were compared using a generalized estimating equations (GEE) model that was adjusted for potential confounding factors to estimate the odds ratios (ORs) and 95% confidence intervals (CIs) for the case cohort.

We used Statistical Analysis System (SAS) 9.3 software (SAS Institute, Cary, NC, USA) to manage and analyze the data. The significance level was set at <0.05, and all tests were two-sided.

Results

Patient characteristics

A total of 85 and 82,717 patients were included in the case and control cohorts, respectively, with an equal number of patients aged 15–45 and an identical proportion of locations of pelvic fractures in both groups. There was no difference between the case and control cohorts (P < 0.001). The average follow-up period for patients in the study cohort was 65.34 ± 47.59 months, the maximum follow-up period was 129.30 months, and the minimum follow-up period was 0.72 months. In the control cohort, the average follow-up time was 47.74 ± 31.58 months, the
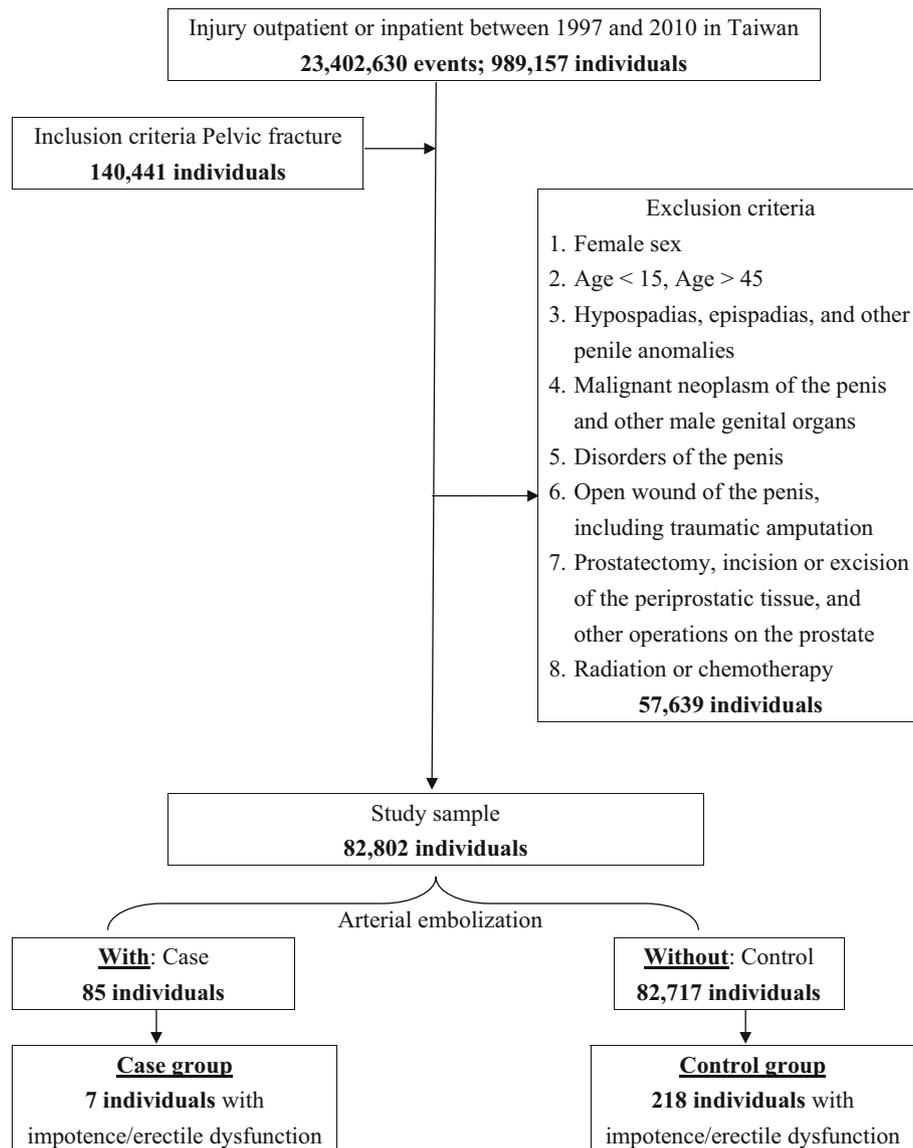
Fig. 1 Flowchart of selection of the study sample from the national health insurance research database between 1997 and 2010

maximum follow-up period was 109.28 months, and the minimum follow-up period was 0.37 months. The proportion of locations of pelvic fracture, age groups, hyperplasia of the prostate, hypertension, diabetes mellitus, hyperglyceridemia, hypercholesterolemia, coronary artery disease, subsequent surgeries, Injury Severity Score (ISS) and urethral injury were identical in the two cohorts. Seven patients in the control cohort had ED (8.24%) compared to 218 patients in the control cohort (0.26%) ($P < 0.001$; Table 1).

We analyzed the cohort using a cross-sectional method. Table 2 shows the group divided into two sub-groups: those with and without ED. In the younger group (aged 15–35 years), patients with pelvic fractures had significantly higher risks of developing ED than older patients

($P < 0.001$). Patients aged 15–45 years with pelvic fractures who subsequently underwent surgery showed significantly higher risks of developing ED than those who did not undergo surgery ($P = 0.002$).

We traced the causes of ED among 15–45-year-old patients with pelvic fractures using logistic regression analysis in the GEE model (Table 3). After adjustment for the influence of confounders, patients aged 36–45 with pelvic fractures showed significantly lower risks of developing ED than those who were younger (adjusted OR: 0.402; CI: 0.274–0.589; $P < 0.001$, Table 3). Patients aged 15–45 years with pelvic fractures who subsequently underwent surgery showed significantly higher risks of developing ED (adjusted OR: 4.251; CI: 2.017–8.960; $P < 0.001$, Table 3).

Table 1 Characteristics of pelvic fractures in male patients aged 15–45 years with or without arterial embolization

Arterial embolization	Total		With (case)		Without (control)		P
Variable	n	%	n	%	n	%	
Total	82,802	100	85	0.10	82,717	99.90	
Erectile dysfunction							<0.001
Without	82,577	99.73	78	91.76	82,499	99.74	
With	225	0.27	7	8.24	218	0.26	
Pelvic fracture							0.079
Acetabulum	20,631	24.92	13	15.29	20,618	24.93	
Pubis	7238	8.74	6	7.06	7232	8.74	
Others	54,933	66.34	66	77.65	54,867	66.33	
Age (years)	29.84±8.67		30.79±7.28		29.84±8.67		0.310
Age group (years)							0.168
15–35	58,017	70.07	55	64.71	57,962	70.07	
36–45	24,785	29.93	30	35.29	24,755	29.93	
Benign prostatic hyperplasia							0.935
Without	82,795	99.99	85	100.00	82,710	99.99	
With	7	0.01	0	0.00	7	0.01	
Hypertension							0.835
Without	82,627	99.79	85	100.00	82,542	99.79	
With	175	0.21	0	0.00	175	0.21	
Diabetes mellitus							0.795
Without	82,579	99.73	85	100.00	82,494	99.73	
With	223	0.27	0	0.00	223	0.27	
Hyperlipidemia							0.628
Without	81,845	98.84	84	98.82	81,761	98.84	
With	957	1.16	1	1.18	956	1.16	
Coronary artery disease							0.985
Without	82,787	99.98	85	100.00	82,702	99.98	
With	15	0.02	0	0.00	15	0.02	
Surgery							0.210
Without	81,971	99.00	83	97.65	81,888	99.00	
With	831	1.00	2	2.35	829	1.00	
Injury severity score ≥16							0.569
Without	82,704	99.34	85	100.00	82,619	99.34	
With	548	0.66	0	0.00	548	0.66	
Urethral injury							0.374
Without	82,406	99.52	85	100.00	82,321	99.52	
With	396	0.48	0	0.00	396	0.48	

P value (categorical variable: Chi-square/Fisher exact test; continuous variable: t test)

Pelvic fracture: acetabulum ICD-9-CM 808.0, 808.1; pubis ICD-9-CM 808.2, 808.3; others: ICD-9-CM 808, 808.4, 808.5, 808.8, 808.9. Hypertension: ICD-9-CM 401-405, Diabetes mellitus: ICD-9-CM 250, Hyperlipidemia: ICD-9-CM 272.0-272.4. Coronary artery disease: ICD-9-CM 410-414, Benign prostatic hyperplasia: ICD-9-CM 600. Injury severity score: ICD-9-CM 959.99, Urethral injury: ICD-9-CM 867.09–867.1, 598.2, 598.8–598.9. ICD-9-CM: international classification of diseases, clinical modification

We also found no relationship between pelvic fractures in male patients aged 15–45 years with arterial embolization and urethral injury. However, pelvic fracture in male patients aged 15–45 years with ED was associated with a higher urethral injury rate (P < 0.001; Table 2).

Risk estimation

After adjusting for possible confounding factors, we found that the incidence of ED in the case cohort was nearly

Table 2 Characteristics of 15–45-year-old patients with pelvic fractures, with and without erectile dysfunction

Erectile dysfunction	Total		With		Without		P
Variable	n	%	n	%	n	%	
Total	82,802		225	0.27	82,577	99.73	
Arterial embolization							<0.001
Without (control)	82,717	99.90	218	96.89	82,499	99.91	
With (case)	85	0.10	7	3.11	78	0.09	
Pelvic fracture							0.002
Acetabulum	20,631	24.92	34	15.11	20,597	24.94	
Pubis	7238	8.74	19	8.44	7219	8.74	
Others	54,933	66.34	172	76.44	54,761	66.32	
Age (years)	29.84±8.67		27.86±6.72		29.84±8.67		0.001
Age group (years)							<0.001
15–35	58,017	70.07	193	85.78	57,824	70.02	
36–45	24,785	29.93	32	14.22	24,753	29.98	
Benign prostatic hyperplasia							0.981
Without	82,795	99.99	225	100.0	82,570	99.99	
With	7	0.01	0	0.00	7	0.01	
Hypertension							0.621
Without	82,627	99.79	225	100.0	82,402	99.79	
With	175	0.21	0	0.00	175	0.21	
Diabetes mellitus							0.545
Without	82,579	99.73	225	100.0	82,354	99.73	
With	223	0.27	0	0.00	223	0.27	
Hyperlipidemia							0.121
Without	81,845	98.84	220	97.78	81,625	98.85	
With	957	1.16	5	2.22	952	1.15	
Coronary artery disease							0.960
Without	82,787	99.98	225	100.00	82,562	99.98	
With	15	0.02	0	0.00	15	0.02	
Surgery							0.002
Without	81,971	99.00	217	96.44	81,754	99.00	
With	831	1.00	8	3.56	823	1.00	
Injury severity score ≥16							0.224
Without	82,254	99.34	225	100.0	82,029	99.34	
With	548	0.66	0	0.00	548	0.66	
Urethral injury							<0.001
Without	82,406	99.52	166	73.78	82,240	99.56	
With	396	0.48	59	26.22	337	0.44	

P value (categorical variable: Chi square/Fisher exact test; continuous variable: t test)

Pelvic fracture: acetabulum ICD-9-CM 808.0, 808.1; pubis ICD-9-CM 808.2, 808.3; others: ICD-9-CM 808, 808.4, 808.5, 808.8, 808.9. Hypertension: ICD-9-CM 401-405, Diabetes mellitus: ICD-9-CM 250, Hyperlipidemia: ICD-9-CM 272.0–272.4. Coronary artery disease: ICD-9-CM 410–414, Benign prostatic hyperplasia: ICD-9-CM 600. Injury severity score: ICD-9-CM 959.99, Urethral injury: ICD-9-CM 867.09–867.1, 598.2, 598.8–598.9. ICD-9-CM: International Classification of Diseases, Clinical Modification

32.637-fold higher than that in the control cohort (adjusted OR: 32.637, 95% CI: 14.137–75.346; $P < 0.001$, Table 3).

The characteristics of the demographic- and comorbidity-specific variables for both study cohorts are shown in Table 1. Patients aged 36–45 years with pelvic fractures showed significantly lower risks of developing ED than younger patients (adjusted OR: 0.402; CI: 0.274–0.589; $P < 0.001$, Table 3).

Table 3 Factors associated with impotence or erectile dysfunction among male patients aged 15–45 years with pelvic fractures using a logistic regression analysis in a generalized estimating equations model

Variables	Crude OR	95%CI	95%CI	*P*	Adjusted OR	95% CI	95% CI	*P*
Arterial embolization								
Without (control)	Reference				Reference			
With (case)	33.962	15.496	74.434	<0.001	32.637	14.137	75.346	<0.001
Pelvic fracture								
Acetabulum	0.526	0.364	0.759	0.001	0.696	0.476	1.018	0.062
Pubis	0.838	0.521	1.347	0.465	1.387	0.852	2.259	0.188
Others	Reference				Reference			
Age group (years)								
15–35	Reference				Reference			
36–45	0.387	0.266	0.563	<0.001	0.402	0.274	0.589	<0.001
Benign prostatic hyperplasia								
Without	Reference				Reference			
With	0.000	–	–	0.999	0.000	–	–	0.999
Hypertension								
Without	Reference				Reference			
With	0.000	–	–	0.995	0.000	–	–	0.996
Diabetes mellitus								
Without	Reference				Reference			
With	0.000	–	–	0.995	0.000	–	–	0.995
Hyperlipidemia								
Without	Reference				Reference			
With	1.949	0.801	4.739	0.141	2.063	0.797	5.343	0.136
Coronary artery disease								
Without	Reference				Reference			
With	0.000	–	–	0.999	0.000	–	–	0.999
Surgery								
Without	Reference				Reference			
With	3.662	1.802	7.441	<0.001	4.251	2.017	8.960	<0.001
Injury severity score ≥16								
Without	Reference				Reference			
With	0.000	–	–	0.993	0.000	–	–	0.993
Urethral injury								
Without	Reference				Reference			
With	86.736	63.251	118.939	<0.001	52.269	36.129	75.619	<0.001

GEE generalized estimating equations, *OR* odds ratio, *CI* confidence interval, *adjusted OR* adjusted variables listed in the table

Pelvic fracture: acetabulum ICD-9-CM 808.0, 808.1; pubis ICD-9-CM 808.2, 808.3; others: ICD-9-CM 808, 808.4, 808.5, 808.8, 808.9. Hypertension: ICD-9-CM 401–405, Diabetes mellitus: ICD-9-CM 250, Hyperlipidemia: ICD-9-CM 272.0–272.4. Coronary artery disease: ICD-9-CM 410–414, Benign prostatic hyperplasia: ICD-9-CM 600. Injury severity score: ICD-9-CM 959.99, Urethral injury: ICD-9-CM 867.09–867.1, 598.2, 598.8–598.9. ICD-9-CM: International Classification of Diseases, Clinical Modification

Patients aged 15–45 years with pelvic fractures who subsequently underwent surgery showed significantly higher risks of developing ED than those who did not undergo surgery (adjusted OR: 4.251; CI: 2.017–8.960; *P* < 0.001; Table 3).

Seven fracture patients developed ED among 85 patients who underwent arterial embolization. In men with pelvic fracture who did not undergo arterial embolization, 218 of 82,717 patients had ED. After comparing the pelvic fracture patients who developed ED based on whether they underwent arterial embolization, we found that there was a statistically significant difference between the two groups (*P* < 0.001; Table 2). Because of the small size of the case cohort, we also used propensity score matching to estimate the effect of ED in pelvic fracture patients who underwent angiographic embolization. In this approach, the

Table 4 Factors associated with impotence or erectile dysfunction among male patients aged 15–45 years with pelvic fractures using a logistic regression analysis in a generalized estimating equations model

Control group	Unmatched				Fourfold propensity score matching			
Variables	Adjusted OR	95% CI	95% CI	P value	Adjusted OR	95% CI	95% CI	P
Arterial embolization (With vs. without)	32.637	14.137	75.346	<0.001	27.626	12.492	61.093	<0.001

GEE generalized estimating equations, *OR* odds ratio, *CI* confidence interval, *adjusted OR* adjusted variables listed in Table 3

Table 5 Proportion of patients with erectile dysfunction with and without arterial embolization after pelvic fracture

	Pelvic fracture	With (study samples)			Without (general population)			Total
	Arterial embolization	With (case group)	Without (control group)	Total	With	Without	Total	
Baseline	N	85	82,717	82,802	11	197,193	197,204	280,006
Erectile dysfunction	N	7	218	225	0	12	12	237
Endpoint	%	8.24	0.26	0.27	0.00	0.01	0.01	0.08

The general population had the same exclusion criteria as the study sample

$P < 0.001$ (study sample with arterial embolization vs. general population with arterial embolization). $P < 0.001$ (study sample without arterial embolization vs. general population without arterial embolization)

contributions of the study subjects were weighted by 1 propensity score for target patients and by 4 (fourfold—propensity score) for control patients. We found that pelvic fracture patients who underwent angiographic embolization had greater risks of developing ED than those who did not undergo the procedure (adjusted OR: 27.626; 95% CI: 12.492–61.093; $P < 0.001$; Table 4).

Discussion

Trauma accounts for approximately 1 in 10 deaths worldwide, and the involvement of pelvic fracture increases the mortality risk [15]. The incidence of traumatic pelvic fracture in Taiwan is 17.17–19.42 per 100,000 people [3]. ED after pelvic injury is known to be associated with neurogenic, vascular, corporal, and psychogenic injury, and complications arise due to arterial embolization [8, 16]. However, to our knowledge, no systematic research has been performed on the association between arterial embolization and ED in patients with pelvic fractures. We performed a comprehensive study using data from outpatients or inpatients from the NHIRD between January 1, 1997 and December 31, 2010. We discovered that there was a strong association between ED and arterial embolization in patients with pelvic fracture, which has never been documented before.

Hemodynamically unstable patients with pelvic fractures frequently receive arterial embolization, Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) and pelvic packing to control arterial bleeding in the pelvis

[17, 18]. Internal iliac artery embolization is an important method of controlling bleeding. The cavernosal artery is the most important vessel involved in ED and branches distally from the internal iliac artery. Many studies have shown an association between arterial embolization and ED in short-term follow-up periods (range: 1–74.1 months) [19]. They found that arterial embolization to control bleeding in pelvic fracture patients did not increase the rate of ED and that the type of pelvic fracture played a major role in the development of ED [19]. In this study, we found that patients with a fracture of the acetabulum were unlikely to develop ED. However, due to the limitations of the NHIRD, the mechanism of pelvic fractures could not be traced.

Our study is the first large-scale long-term cohort study to discuss the association between pelvic fracture and pelvic angiographic embolization in patients with ED. According to our findings, pelvic angiographic embolization was correlated with the risk of ED. After controlling for other important covariates, we found that male fracture patients had a 32.637-fold increased risk of developing ED if they were treated with angiographic embolization.

Many researchers have evaluated the safety of pelvic angiographic embolization for the treatment of pelvic fractures in hemodynamically unstable patients. They concluded that arterial embolization is a safe and effective non-surgical method [20, 21]. Several complications have been reported after internal iliac arterial embolization, such as gluteal necrosis, perineal necrosis, bladder necrosis, urinary retention, femoral head necrosis, bowel infarction,

Table 6 Rate of impotence or erectile dysfunction among male patients aged 15–45 years

Group	Population	Impotence/erectile dysfunction	Rate (%)
(A) With pelvic fracture, with arterial embolization	85	7	8.24
(B) With pelvic fracture, without arterial embolization	82,717	218	0.26
(C) Without pelvic fracture, with arterial embolization	11	0	0
(D) Without pelvic fracture, without arterial embolization	197,193	48	0.05

$P < 0.001$, A > B > D > C

rhabdomyolysis, ED, and sciatic or sacral plexus palsy [22–24].

In this study, we focused on the causes of ED following arterial embolization. The common causes of ED following arterial embolization may be the level of embolization, bilateral nonselective embolization, and embolization technique. Arteriogenic-, neurogenic-, and mixed-etiology ED may occur in patients with pelvic fracture injury. Therefore, we evaluated the cohort group using a cross-sectional method, dividing the group into two sub-groups of patients who did and did not receive arterial embolization with ED as the endpoint. We found that there was a significantly higher rate of ED in patients with pelvic fracture who underwent arterial embolization than in those who did not (Table 5).

We also compared the study sample with a sample from the general arterial embolization population and found that there was a higher ED rate in the study sample. The same results were also found in a sample of patients who did not receive arterial embolization. Therefore, these pelvic fracture patients who underwent arterial embolization had a higher risk of having ED after long-term follow-up than those who did not undergo arterial embolization or members of the general population. The same results were also seen after potential confounding factors were adjusted in the GEE model.

We also found that ED occurred more often in younger patients who underwent arterial embolization than in those who were older. This result is similar to that of other studies, and the mechanisms of ED may be neurogenic, arteriogenic, or mixed-etiology [25]. Patients who subsequently underwent surgery had a higher risk of developing ED, a conclusion that is similar to that of many other researchers. This might be because patients with pelvic fractures and urethral injury who needed further reconstruction had more severe injuries than uninjured patients [26, 27]. In this study, patients with pelvic fractures who subsequently underwent surgery all received urethral repair surgery.

This study has a number of strengths. First, the sample size was large, which enhances the statistical power of the findings. We used stratified analyses according to age, type of pelvic fracture, and comorbidities, and assessed a wide range of demographic characteristics. Second, because of the nationwide database used, which has a very high coverage rate, almost all patients' follow-up data were available. Third, the population-based data that were used represent the general population in Taiwan. It is worth mentioning that ED and consent issue when dealing with patients in hypovolemic shock and other treatment options.

Limitations

This study also has some limitations that should be discussed. First, this was a retrospective cohort study, which has low statistical quality. Bias from unknown confounders may have affected our results, and a well-designed, prospective, randomized control study is needed in the future to help establish a causal relationship between arterial embolization and ED. Second, the NHIRD does not offer some information, such as data on IIEF criteria, NPT, duplex ultrasonography, cavernosography, and neurophysiological, which may have influenced our results. Third, some important clinical information, such as surgical notes, highly selective or selective embolization, embolization materials, radiation exposure time, unilateral or bilateral vessel embolization, frequency of arterial embolization, and imaging results were not available because the patient data in the NHIRD were anonymous. Fourth, a time-related bias may exist due to different index dates and follow-up times in the study cohorts. Fifth, ED seems to occur in a very small number of patients (7/85 [8.24%] of cases and 218/82,717 [0.26%] of controls; 0.05% is the baseline rate of sexual dysfunction in this patient population, Table 6); although the OR of 32.637 was statistically significant, the clinical relevance of this finding at such a low incidence should be interpreted with caution.

Conclusion

In Taiwan, arterial embolization in male pelvic fracture patients is associated with an increased risk of developing ED. Physicians should weigh the procedure's benefits against its possible adverse complications and

communicate the possible risks to patients. Although the procedure can cause some complications, physicians can reduce the risks by using highly selective unilateral embolization whenever possible.

Compliance with ethical standards

Conflict of interests All authors declare no conflict of interest.

Data availability statement All data are fully available without restriction.

Ethical approval The study methods were reviewed and approved by the Institutional Review Board II of the Tri-Service General Hospital, National Defense Medical Center.

Ethical standards The disease diagnoses were based on the International Classification of Diseases, Ninth Revision, Clinical Modification. These data were all disconnected to these patients, and we did not really contact these patients. So informed consent of the study participants was not required and approved by the Institutional Review Board II of the Tri-Service General Hospital, National Defense Medical Center No 1-105-05-050.

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