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Iatrogenic Vascular Injuries in Sweden. A Nationwide Study 1987–2005☆

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Objectives. *To study the epidemiology of vascular injuries, with special focus on Iatrogenic Vascular Injuries (IVIs) and time-trends.*
Design and methods. *From the Swedish national vascular registry, Swedvasc, prospectively registered data on vascular injuries during 1987–2005 were analysed and cross-referenced for mortalityagainst the population registry.*
Results. *Of 1853 injuries, 48% were caused by iatrogenic, 29% penetrating and 23% blunt trauma. In the three groups median age was 68, 35 and 40 years, respectively. The annual incidence of procedures for vascular injuries increased from 1.2–1.6 per 100 000 inhabitants and the proportion of IVIs increased from 41 to 51%, during the period. Mortality was higher after IVI (4.9%) compared to non-IVI (2.5%). Patients with IVI also had more co-morbidities; 58% cardiac disease, 44% hypertension, and 18% renal dysfunction.*

Among 888 IVIs, right femoral arterial injury was the most frequent (37%). The most common vascular reconstruction was direct suture (39%) followed by by-pass or interposition graft (19%, of which prosthetics were used in over half the cases). Endovascular repair increased from 4.6% to 15% between 1987 and 2005.
Conclusions. *Vascular injuries, in particular iatrogenic ones, appear to be increasing. Iatrogenic injuries affect vulnerable patients with co-morbidities and are associated with a high mortality.*

Keywords: Iatrogenic; Vascular injury; Arterial injury; Vascular trauma.

Introduction

While trauma has been a rare indication for vascular surgery in Sweden[1,2] reports indicate that the incidence of civil vascular injuries is increasing, mostly a result of increasing numbers of iatrogenic vascular injuries (IVIs).[3,4] This increase seems to be associated with the introduction of percutaneous transluminal angioplasty and cardiac catheterization[5,6] and studies show that the increasing number of percutaneous arterial interventions is the principal cause of IVI.[6–8]

The incidence of vascular trauma is uncertain in most countries and the relative occurrence and severity of IVIs compared with non iatrogenic injuries is not well established. The history of IVIs has implications for patient safety and on overall results after vascular interventions.

The primary aim of this report is to describe and analyse vascular injuries, with emphasis on iatrogenic injuries, in a nation-wide population-based registry. Secondary aims are to estimate the incidence of vascular injuries and the frequency in relation to the vascular surgical volume including time-trends, to describe the anatomic distribution and treatment of the injuries and to identify risk factors associated with fatal outcome.

Material and Methods

Study population and the registry

The Swedish vascular registry (Swedvasc) started in 1987. By January 1994 all 42 hospitals performing vascular surgery in Sweden participated. The Swedvasc is validated externally and compared each year with the In-Patient Registry, used for reimbursement, showing that the reporting rate ishigher than 90 per cent.[9] To minimise the number of cases lost to follow up, a list of patients awaiting one-year follow-up was sent to each centre on a monthly basis and from 2003 the Internet-based system delivers regular reminders. The follow-up rate at 30 days exceeds 90 per cent.[10]

The internal validity of the Registry has been evaluated in depth in several research projects, verifying

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☆ On behalf of the Swedvasc.
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a high internal validity in core surgery such as operations for abdominal aortic aneurysm,[11] carotid artery surgery[12] and popliteal artery aneurysm.[13]

During study period January 1987 until December 2005 a total of 138 289 vascular surgical procedures (open or endovascular) were reported to the Registry (by March 2006).

Co-morbidities and risk factors such as hypertension, diabetes mellitus, chronic obstructive pulmonary disease, cerebrovascular disease, renal disease, previous vascular surgery or amputation due to peripheral ischaemia are registered at the time of the primary operation for vascular injury, according to Swedvasc protocol. Cardiac morbidity is defined as history of cardiac operation, myocardial infarction, heart failure, angina pectoris and/or atrial fibrillation. Renal impairment is defined as a creatinine >150 μmol/l. Diabetes is defined when treated with diet, insulin or oral medication. Although smoking is an important risk factor, it is difficult to obtain valid data from patient interview and biochemical verification is needed. There was considerable missing information about smoking in those with vascular injuries, many of whom were treated as an emergency and were in-patients in non vascular surgery departments. Therefore smoking was not used as a risk factor. Other variables registered prospectively include the anatomy of the reconstruction, type of operation and graft, survival and complications.

Retrieval and definition of cases

Vascular injury in this study was defined as a major vessel injury, needing an open surgical or endovascular procedure involving a vascular surgeon or interventionalist, thus being eligible for reporting to the Swedvasc. This definition of vascular injuries excludes patients who die before arrival at hospital, vascular injuries not requiring repair by a surgeon reporting to the Swedvasc, or not requiring any repair.

In the Swedvasc Registry it is impossible to register a procedure without describing the indication for surgery. A maximum of three indications can be registered from a list of 41 alternatives, three of them being: Vascular injury − blunt trauma, Vascular injury −penetrating trauma and Vascular injury − iatrogenic trauma. The distinction between blunt and penetrating trauma is based on whether the skin has been penetrated. Thus, a closed fracture with a sharp bone penetrating a blood-vessel is classified as a blunt trauma, but a stab wound would be classified as penetrating. Although the focus of this paper is on IVIs, non-IVIs also are reported.

This report is based on Registry data only and no attempts were made to retrieve complete case-records from the various hospitals.

Estimation of population incidence

It is possible to estimate the incidence of injuries from January 1994, which was when Swedvasc attained national coverage. The following 12 years until December 2005 were divided into 3 four-year periods. Time trends in incidence were analysed between these time intervals. The population of Sweden increased from 8 816 000 in January 1994 to 9 053 000 in January 2006.[14]

Postoperative complications

As specified in the Swedvasc protocol, the 30-day postoperative follow-up visit included assessment of general complications, surgical complications and re-operations. Re-operations were vascular or non-vascular operations such as amputation, fasciotomy and re-laparotomy for non-vascular indications.

General complications were classified into cardiac, cerebrovascular, renal, pulmonary, venous thrombosis and prolonged ICU stay (>5 days). Surgical complications were classified as bleeding, superficial or deep wound infection (including graft infection) and occlusion of the vascular reconstruction. The protocol has been reported previously in detail.[10]

Long-term survival

Mortality data (date of death) were obtained by cross-reference to the Population Register, with follow up until 5th of November 2006, by using the unique personal identity code (with permission from the national data-security authority), resulting in complete data for survival. Mean follow up for IVIs was 5.0 (0.0−19.3) years and for non-IVIs 7.4 (0.0−19.7) years, and the study covered a total of 11 250 person-years of follow up for survival. Only 6 (0.3%) patients were lost to long-term follow-up, arising either when the patient was a non-Swedish citizen or when an incorrect personal identity code was registered.

Ethical considerations

According to the rules of the Swedvasc informed consent is required from all patients prior to registration, with the exception of fatal cases, which are exempted according to Swedish law. All involved Swedish Regional Ethics Committees have approved the Swedvasc

Registry. In this study, anonymous data was analysed, with permission granted by the Steering Committee of the Swedvasc.

Statistical methods

In the evaluation of preoperative risk factors for 30-day outcome, proportions were compared by the chi-square test and expressed in terms of odds ratios with 95% confidence intervals. Distributions were compared by two-tailed Student's t-test with Levene's test for equality of variances. Long-term survival rates were compared using the Kaplan-Meier method and the generalised Wilcoxon test for univariate analyses and Cox regression analysis for multivariate models. The anatomic distribution in arterial injury cases and arterial surgery overall was compared by indirect standardisation to overall rates, with expression of standardised morbidity ratio (SMR) between observed number of vascular injury cases involving each anatomical site, and the expected number based on the overall vascular injury percentage and the number of vascular surgery cases involving that site, for the three indications studied.

Results

Vascular injuries: rates and time trends

From January 1st 1987 until December 31st 2005, 1853 open or endovascular operations on 1793 patients with vascular injuries were reported to the Swedvasc. Of these, 888 (48%) were IVIs in 856 patients. Of the 965 non-iatrogenic injuries (non-IVIs), 530 (55%) were caused by penetrating and 435 (45%) by blunt trauma, 514 and 421 patients respectively. Vascular injury repairs constituted 1.3% of all registered vascular procedures (1853 of 138289).

Incidence of vascular injuries

The average number of vascular injuries was 127 per year 1994–2005, but increased from 87 in 1994 to 180 in 2005. The proportion caused by iatrogenic trauma increased, from 41% during the 4-year-period 1994 to 1997 to 51% 2002–2005 (Fig. 1). While the number of registered procedures per year in the registry was stable during this 12-year period, the proportion of procedures for IVI increased from 0.57 to 0.79 % from the first to the last 4-year period (Table 1).

The average annual incidence of vascular injury was 1.2 per 100 000 inhabitants during 1994–1997 and increased to 1.6 per 100 000 inhabitants 2002–2005. This increase is mainly explained by the increase of iatrogenic injuries.

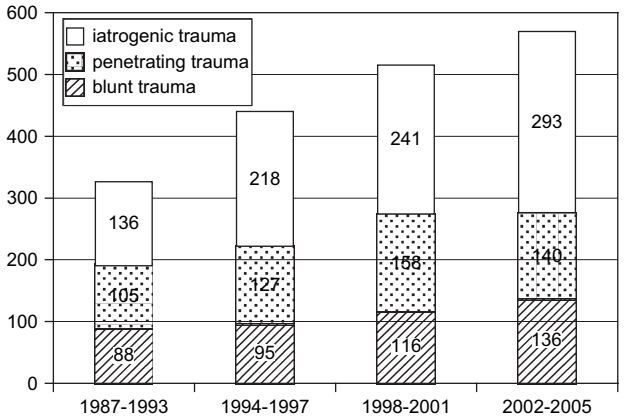

Fig. 1. Vascular injuries (1853 cases) depending on type of trauma during 4 time periods.

Patient characteristics

In the group of patients suffering iatrogenic vascular injuries the gender distribution was balanced (49% men), but men predominated among blunt (69%) and penetrating (83%) vascular injuries. Median age among patients suffering IVIs was 68 years (range 3–92), compared to 40 (1–103) after blunt and 35 (0–97) after penetrating injuries.

The rates of co-morbidities among patients with IVI were high; 58% had cardiac disease, 44% hypertension and 18% renal dysfunction (creatinine $>$ 150 mmol/l).

Among patients with non-IVIs the most frequent co-morbidities were hypertension (6.1%), cardiac disease (5.8%), followed by diabetes mellitus (2.5%).

Anatomic location of injuries

Of the 888 procedures for IVI 768 (86%) were arterial, 80 (9%) venous and 40 (5%) graft injuries. Among the graft injuries four were on dialysis access grafts.

Table 1. Proportion of vascular surgery caused by iatrogenic vascular injuries (IVIs)

	Registered procedures of vascular surgery overall	IVIs	%
*1997–1993**	*23830**	*136*	*0.57*
1994–1997	38912	218	0.56
1998–2001	38246	241	0.63
2002–2005	37301	293	0.79
Total	138289	888	0.64

* Not yet national coverage.

Among the arterial IVIs 58% affected the lower and 9% the upper extremities (Fig. 2). The anatomic distribution of IVIs with lethal outcome within 30 days was different. Among 42 patients with lethal outcome proximal injuries, to the abdominal aorta (15%), iliac (20%) or cervical arteries (10%) were seen more often, although femoral artery injuries also were common in this group of patients (28%).

Among the 965 procedures for non-IVIs, 39 (4.0%) were venous and one was a graft injury (0.1%). Among the remaining 925 arterial injuries, 421 (45%) affected the upper and 337 (36%) affected the lower extremities (Fig. 3). The left upper extremity (28%) was the most common site of the arterial non-IVIs. Injuries to the radial or ulnar arteries (142) were penetrating in 98% and left-sided in 67% of the procedures. In the calf,the posterior tibial artery was injured in 69% (41/59). Of injuries to the cervical vessels, 88% (29/32) were due to penetrating trauma and 76% (25/33) were on the left side. Four (13%) of the patients with cervical injuries died during the first four postoperative days but all the others were alive at the end of follow-up (median 5.3 years, 1.5–17.8).

In the group of non-IVI patients who died within 30 days (23 patients), the distribution between upper and lower extremities was 34% and 30% respectively, 17% having injured the cervical vessels. The left-sided injuries predominated(74%), and penetrating trauma accounted for 65%.

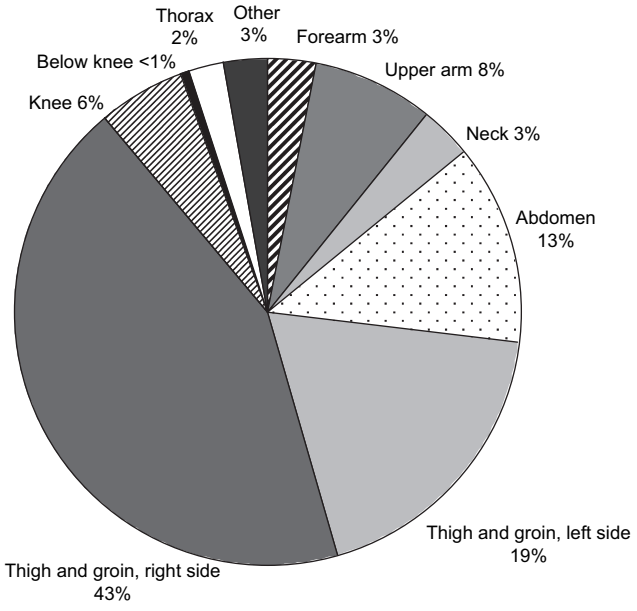

Fig. 2. Sites of arterial vascular injuries among IVIs (768 cases). The injuries to the subclavian artery were included among the thoracic injuries.

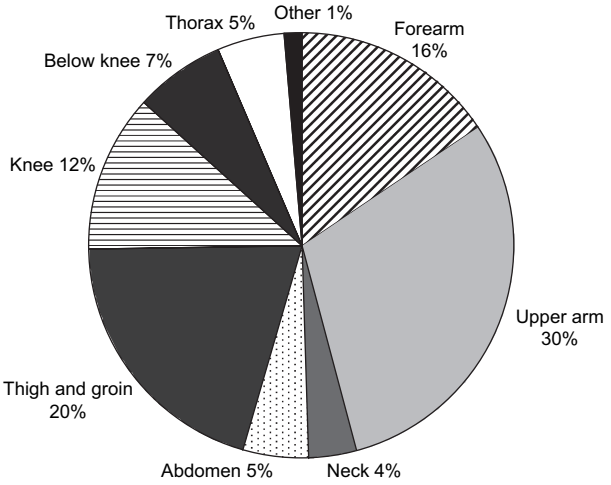

Fig. 3. Sites of arterial vascular injuries among non-IVIs (942 cases). The injuries to the subclavian artery were included among the thoracic injuries.

When comparing the anatomic distributions for arterial surgery due to vascular injuries and with overall arterial surgery in Sweden (Table 2) there was a significant association between SMR and fatal outcome for the vertebral arteries (SMR = 15, 60% mortality, 3/5 patients). Not only was surgery on the vertebral artery 15 times more common after vascular injury than after other vascular surgical indications, these procedures also were associated with an increased mortality. Among the visceral arteries the celiac trunk had an SMR of 10.9, for IVIs.

Type of vascular repair

Emergency repair was performed in 75% of the IVIs. The most common surgical procedure was direct suture repair of the vessel (39%), followed by bypass or interposition graft (19%), thrombo-embolectomy (11%), endovascular repair (9%), exploration only (8%), patch angioplasty (6%) and direct repair with end-to-end anastomosis (3%). When reconstruction was performed with a bypass, interposition graft or a patch, prosthetic material (61% PTFE) was used in 150 (55%), vein in 108 (39%) and composite grafts in 16 (6%) cases. Endovascular repair increased during the study-period: from 4.6% (1994–1997) to 15% (2002–2005) (Table 3).

Among non-IVIs emergency repair was performed in 93%. The most common surgical procedures were: bypass or interposition graft (41%), direct suture (18%), direct repair with end-to-end anastomosis (12%), exploration only (12%), patch angioplasty (7%) and endovascular repair (3%).

Table 2. Comparison of the anatomic distribution between arterial surgery due to vascular injuries and arterial surgery overall in the Swedvasc. Standardised morbidity ratios (SMR) between observed and expected number of cases

Arterial segment involved	All indications for arterial surgery	Surgery for arterial injury					
		All injuries		Iatrogenic		Non-iatrogenic	
	N	*N*	*SMR**	*N*	*SMR*	*N*	*SMR*
Common carotid	10100	64	*0,5*	38	*0,7*	26	*0,4*
External carotid	325	16	*4,0*	2	*1,1*	14	*6,5*
Internal carotid	9842	19	*0,2*	7	*0,1*	12	*0,2*
Vertebral	54	10	*15,0*	2	*6,5*	8	*22,3*
Subclavian/axillary	2577	181	*5,7*	47	*3,2*	134	*7,8*
Brachial	8874	555	*5,1*	88	*1,7*	467	*7,9*
Radial	7764	282	*2,9*	46	*1,0*	236	*4,6*
Ulnar	333	59	*14,4*	3	*1,6*	56	*25,3*
Thoracic aorta	1410	54	*3,1*	4	*0,5*	50	*5,3*
Abdominal aorta	48681	104	*0,2*	61	*0,2*	43	*0,1*
Visceral	4346	82	*1,5*	49	*2,0*	33	*1,1*
Common iliac	26962	101	*0,3*	84	*0,5*	17	*0,1*
External iliac	16758	175	*0,8*	151	*1,6*	24	*0,2*
Internal iliac	771	32	*3,4*	11	*2,5*	21	*4,1*
Common femoral	52703	706	*1,1*	626	*2,1*	80	*0,2*
Superficial femoral	30187	304	*0,8*	113	*0,7*	191	*1,0*
Deep femoral	6086	90	*1,2*	74	*2,1*	16	*0,4*
Popliteal	30950	342	*0,9*	109	*0,6*	233	*1,1*
Anterior tibial	4494	41	*0,7*	9	*0,4*	32	*1,1*
Tibiofibular trunc	2228	19	*0,7*	8	*0,6*	11	*0,7*
Posterior tibial	4021	125	*2,5*	16	*0,7*	109	*4,1*
Fibular	3777	12	*0,3*	7	*0,3*	5	*0,2*
All	*273243*	*3373*	*1,0*	*1555*	*1,0*	*1818*	*1,0*

* A SMR of e.g. 4,0 indicating that this anatomical location was four times as common after repair of a vascular injury than after vascular surgical procedures in general in Swedvasc.

Outcome

At 30 days the all-cause mortality among patients suffering IVIs was 4.9% compared to 2.9% after penetrating and 1.9% after blunt injury.

Patients with IVIs with fatal outcome within 30-days were older (median age 76 years, range 33–89) and had more comorbidities than survivors (median 67, range 2–92) (Table 4).

Among these 42 cases of IVIs with early fatal outcome bypass surgery or interposition grafts were used in 25% of the cases (19% among survivors), and the frequency of occlusion of the reconstruction (7/38) was higher than among survivors (36/754) ($p < 0.001$).

Patients with an IVI in an abdominal or cervical artery (140/768) had a higher mortality rate the first postoperative month (11%) compared with those who had a peripheral arterial injury (3.8%) ($p = 0.0016$ OR = 2.9, 95% CI: 1.5–5.6). There was no difference in long-term survival between these two groups although peripheral IVIs had a higher mean age, 64.8 years compared to 58.9 ($p = 0.001$).

Fig. 4 illustrates long-term survival rates in patients suffering the three types of injuries. An association between co-morbidities and long-term mortality among IVIs was found (Table 5). Diabetes, previous vascular surgery and renal impairment appeared to be risk factors, independent of age and other co-morbidities. No gender differences in survival were found ($p = 0.447$).

Among the patients suffering IVIs, 402 (47%) were treated at a university hospital. They had a better survival compared with cases treated at county hospitals ($p = 0.010$). However, they were younger, mean age, 62.0 years compared to 65.5 ($p = 0.001$) at county hospitals and after adjustment for age there was no difference in long-term survival. 30-day mortality was similar in the two types of hospital.

Patients operated on for IVIs suffered general complications with the following frequencies: 3.0% cardiac, 1.3% pulmonary, 1.0% renal, and 1.3% multiorgan failures. The most common surgical complications were graft occlusion (5.9%), bleeding (6.1%), and wound infection (5.5%). Fasciotomy was performed in 2.2%. At

Table 3. Endovascular repairs of IVIs

	PTA	Stent	Stentgraft	Trombolysis	of total IVIs	%
1987–1993	4				139	2.9%
1994–1997	10				217	4.6%
1998–2001	21		1	1	241	9.5%
2002–2005	24	9	8	4	294	15%

Table 4. Co-morbidities and risk-factors for 30 day mortality after IVIs (814 survivors and 42 non-survivors)

Co-morbidity	No. at risk*	No. (%) with co-morbidity survivors	No. (%) with co-morbidity non-survivors	OR	p**
Diabetes mellitus	648	97 (16%)	11 (37%)	3.1 (1.5–6.5)	0.003
Renal impairment[1]	669	106 (17%)	14 (44%)	3.9 (2.0–7.7)	<0.001
COPD[2]	640	55 (9%)	7 (23%)	2.9 (1.3–6.9)	0.013
Age > 68	849	376 (47%)	29 (69%)	2.6 (1.3–4.9)	0.004
Cardiac disease	722	397 (58%)	24 (65%)		0.41
Hypertension	643	267 (44%)	16 (52%)		0.38
Previous vascular surgery	699	268 (40%)	15 (46%)		0.55
Male gender	852	388 (48%)	20 (47%)		0.97

* No. at risk is the number of patients with data regarding this particular risk factor, which was missing in a proportion of cases.
** χ^2 –test comparing cases with lethal outcome within 30 days.
[1] Creatinine > 150 mmol/l.
[2] Chronic obstructive pulmonary disease.

30 days 66 cases (8%) were lost to follow-up with respect to complications.

Among patients with IVIs, treated with bypass or interposition graft (164 patients) 9.6% had an occluded reconstruction and 6.8% had had a major limb amputation within 30 days. There were no differences in occlusion rate (vein 5/66 versus prosthetic 8/84, $p = 0.67$), or amputation rate (vein 2/66 versus prosthetic 7/84, $p = 0.2$) or graft infection rate according to graft material. Patients who received a vein graft were younger (mean age 55yo) than patients who received a prosthetic graft (67yo, $p < 0.001$). In 14 patients graft material was unknown. Dacron was used in more proximal injuries than PTFE. There were no differences in occlusion (6.7% vs. 11%) or graft infection rate (none).

When a prosthetic graft was used for bypass, interposition or patch the rate of graft-infection was higher among non-IVIs (6.4%, 3/47) than among IVIs (0.7%, 1/138) ($p = 0.022$ OR = 0.11). Repair with endografts were few (9 among IVIs and 17 among nonIVIs), but no graft infections were reported.

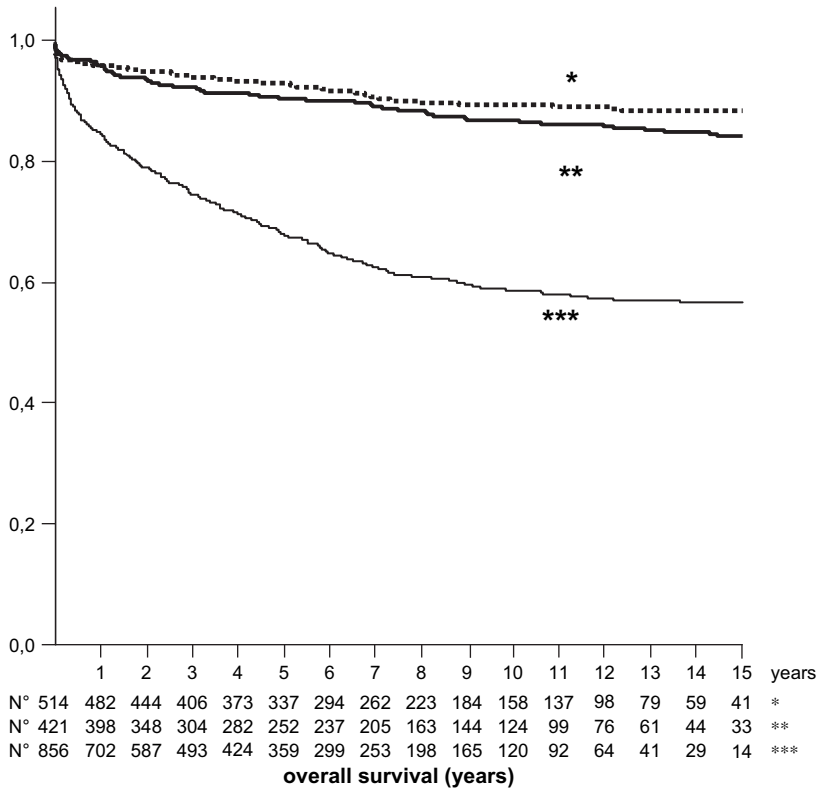

Fig. 4. Type of vascular trauma and cumulative survival (Kaplan-Meier). Number at risk * Penetrating trauma ** Blunt trauma *** Iatrogenic trauma.

Table 5. Pre-operative risk factors for long term mortality among patients operated on for iatrogenic vascular injuries

Risk factor		No. of patients	No. of deaths (%)	Mean follow-up years	Deaths per 100 person years	*p*-value adjusted for age*	RR	*p*-value multivariate analysis**
Age, years	>68	405	245 (60%)	4.1	9.7			
	≤68	444	127 (29%)	5.8	7.6		2.9 (2.2–3.8)	<0.001
Hypertension	Yes	283	142 (50%)	4.2	11.9			
	No	360	138 (38%)	5.4	7.2	0.033	1.2 (0.9–1.6)	0.13
Diabetes	Yes	108	67 (62%)	3.5	17.8			
	No	540	210 (39%)	5.1	7.7	<0.001	1.6 (1.2–2.2)	0.003
Cardiac disease	Yes	421	208 (49%)	4.4	11.6			
	No	301	105 (35%)	5.4	6.5	0.072	–	–
Pulmonary disease	Yes	62	35 (56%)	5.0	16.5			
	No	578	241 (42%)	5.4	8.5	0.002	1.5 (1.0–2.2)	0.062
Cerebrovascular disease	Yes	69	37 (54%)	3.5	16			
	No	577	240 (42%)	5.0	8.4	0.012	1.3 (0.9–1.9)	0.244
Previous vascular surgery	Yes	283	155 (55%)	4.0	13.8			
	No	416	150 (36%)	5.3	6.9	<0.001	1.4 (1.0–1.7)	0.022
Renal impairment	Yes	120	78 (65%)	2.9	22.5			
	No	549	215 (39%)	5.1	7.7	<0.001	2.2 (1.6–3.0)	<0.001

* Age-adjusted COX regression analysis.
** COX regression model including all significant risk factors as covariates.

In the group of patients suffering blunt vascular trauma, 23% were still hospitalized at 30-days, compared to 10% of patients with a penetrating vascular trauma and 13% after IVI. This is probably due to a higher frequency of multiple trauma among blunt trauma cases (i.e. vehicle accidents, fall from heights).

The patients with non-IVIs who died within 30 days were older (mean 54 years) than survivors (39 years) ($p = 0.004$). Among patients suffering non-IVIs, the cumulative 5-year survival rate was 90% (Fig. 4). There was no difference in long-term survival between patients suffering blunt or penetrating trauma ($p = 0.082$).

Discussion

During the last four years of the present study, iatrogenic injuries constituted more than 50% of all vascular injuries in Sweden, a higher proportion than reported from other European countries (Austria 35%, Spain 40% and Finland 42%)[15] and single-centres (Portland, USA 34% and Athens, Greece 36%).[4,6] Such differences may have several causes; inference on absolute risks can only be made in population-based studies. As a result, the actual incidence of vascular trauma in most countries is unknown. As the present study encompassed all vascular surgery performed in the Swedish population, it allows estimations of incidence, which was found to increase by one third, from 1.2 to 1.6 per 100 000 person years over the 12-year time period. The estimated IVI incidence of 1.6 per 100 000 person-years in this report is probably an underestimation, since only those requiring vascular surgery were included.

Common patterns characterise most IVIs. The higher mortality after IVIs than after blunt and penetrating vascular trauma is consistent with reports from earlier studies,[4,6] and reflects underlying differences between these populations: IVIs affect a more vulnerable group of patients, older and with more co-morbidities.

Gun shot wounds are rare in Sweden (approximately 195/year, with a mortality of 7%)[16] as are serious stab injuries (164/year, mortality 3.5%).[17] It is possible that in a different, more violent, environment with a higher incidence of multiple or serious penetrating injuries, the short and long-term mortality after non-IVI might exceed that after IVI. The anatomic pattern differed between iatrogenic and other vascular trauma. For IVI, injuries in the right groin predominated. We assume this is likely due to the great number of therapeutic and diagnostic procedures performed by percutaneous arterial punctures. The right femoral artery is the most common access site for PTCA and other endovascular interventions. Right femoral artery injuries reduced from 39.4% (1994–1997) to 35.8% (2002–2005) of total IVIs. A change of vascular access from the transfemoral to a transradial access and new closure devices might reduce the femoral artery complications, but we have no data to support this. Oweida *et al.* reviewed 4988 percutaneous

transluminal coronary angioplasties and reported the arterial complication rate to be 1%.[18] This is a fairly low incidence, but since PTCA is such a frequent procedure, the volume of the problem becomes significant.

Most non-IVIs injuries occur on the left side, especially on the neck, perhaps due to attackers being right handed.[19–21] Self-inflicted injuries may also have a left-sidedpredominance since most people are right-handed.

The frequency of endovascular repair after IVIs increased over time as well as the number of endovascular options, stents and stentgrafts being used more frequently during the later time-period. These endovascular options, as well as hybrid procedures, constitute additional therapeutic modalities. Further analysis of the role of endovascular repair of IVI will be an important future consideration.

The limitations of this study include possible underreporting to the registry[22] and the exclusion of IVIs not requiring surgical repair. Another limitation is that we based this report on Registry data from the Swedvasc and the Population Registry only, without access to complete case-records, so are without information about the mechanism of trauma, associated injuries and co-morbidities. In addition most false aneurysms occurring as a result of femoral artery puncture today are treated by ultrasound-guided compression or injection of recombinant thrombin, procedures not reported to Swedvasc.

Conclusions

Iatrogenic vascular injuries form a substantial proportion of vascular injuries in Sweden, both the proportion and crude numbers are increasing with time. Such injuries have a different anatomic distribution to those resulting from non-iatrogenic vascular trauma. In addition, iatrogenic vascular trauma affects an older, more vulnerable group of patients with many co-morbidities, with attendant increase of 30 day mortality.

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References

1 Jonung T, Parsson H, Norgren L. Vascular injuries in Sweden 1986–1990: the result of an enquiry. *VASA* 1995;**24**(2):130–134.
2 Bergqvist D, Myhre HO. Arterial surgery in Scandinavia. *World J Surg* 1984;**8**:71–75.
3 Bergqvist D, Helfer M, Jensen N, Tagil M. Trends in civilian vascular trauma during 30 years. *Acta Chir Scand* 1987;**153**:417–422.
4 Giswold M, Landry G, Taylor L, Moneta G. Iatrogenic arterial injury is an increasingly inportant cause of arterial trauma. *Am J Surg* 2004;**187**:590–593.
5 Bergqvist D, Jonsson K, Weibull H. An analysis of complications to percutaneous transluminal angioplasty of extremity and renal arteries. *Acta Radiol* 1987;**28**:3–12.
6 Lazarides MK, Tsoupanos S, Georgopoulos S, Chronopoulos A, Arvanitis DP, Doundoulakis NJ. Incidence and patterns of Iatrogenic arterial injuries. A decade's experience. *J Cardiovasc Surg* 1998;**39**:281–285.
7 Hatakeyama T, Shigematsu H, Muto T. Results of surgical treatment for vascular injuries. *Surg Today* 2000;**30**(3):235–240.
8 Nehler M, Taylor L, Porter J. Iatrogenic vascular trauma. *Semin Vasc Surg* 1998;**11**(4):283–293.
9 Troëng T, Forssell C, Lundell A, Karlström L, Hedin U, Malmstedt J *et al.* Nationella kvalitetsregistret för kärlkirurgi. SWEDVASC, Yearly Report, 2007 (on the activity of 2006). Available (In Swedish) at: www.swedvasc.se
10 Bergqvist D, Troëng T, Elfström J, Hedber GB, Ljungström K-G, Norgren L *et al*. Auditing Surgical Outcome. Ten years with the SWEDVASC. *Eur J Surg* 1998;**164**(Suppl):581.
11 Björck M, Bergqvist D, Troëng T. Incidence and clinical presentation of bowel ischaemia after aortoiliac surgery - 2930 operations from a population-based registry in Sweden. *Eur J Vasc Endovasc Surg* 1996;**12**:139–149.
12 Kragsterman B, Pärsson H, Bergqvist D, Björck M. Outcomes of carotid endarterectomy for asymptomatic stenosis in Sweden are improving– results from a population based registry. *J Vasc Surg* 2006;**44**:79–85.
13 Ravn H, Bergqvist D, Björck M. Nationwide study of the outcome of popliteal artery aneurysms treated surgically. *Br J Surg* 2007 May 22 (E-pub ahead of print).
14 Statistics Sweden. Source: SCB. http://www.scb.se
15 Fingerhut A, Leppäniemi AK, Androulakis G, Archodovassilis F, Bouillon B, Carina E *et al*. The European experience with vascular injuries. *Surg Clin North Am* 2002 Feb;**82**(1):175–188.
16 Boström L, Nilsson B. A review of serious injury and death from gun shot wounds in Sweden:1987–1994. *Eur J Surg* 1999 Oct; **165**(10):930–936.
17 Boström L, Heinius G, Nilsson G. Trends in the incidence and severity of stab wounds in Sweden 1987–1994. *Eur J Surg* 2000 Oct; **166**(10):765–770.
18 Oweida SW, Roubin GS, Smith RB, Salam AA. Postcatheterization vascular complications associated with percutaneous transluminal coronary angioplasty. *J Vasc Surg* 1990;**12**:310–315.
19 Schmidt U, Pollak S. Sharp force injuries in clinical forensic medicine-Findings in victims and perpetrators. *Forensic Sci Int* 2006;**159**:113–118.
20 Katkici U, Ozkok MS, Orsal M. An autopsy evaluation of defence wounds in 195 homicidal deaths due to stabbing. *J Forensic Sci Soc* 1994;**34**(4):237–240.
21 De Villiers J, Grant A. Stab wounds at the craniocervical junction. *Neurosurgery* 1985;**17**(6):930–936.
22 Rothwell P, Warlow C. Is self-audit reliable? *Lancet* 1995;**346**:1623.

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