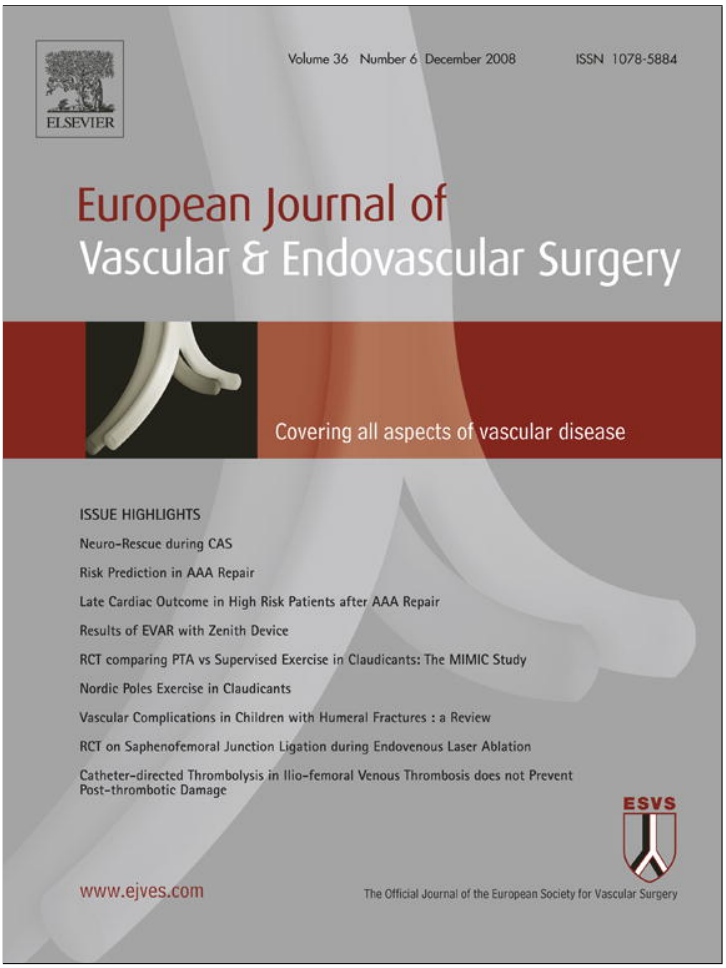

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External Validation of the Swedvasc Registry: A First-time Individual Cross-matching with the Unique Personal Identity Number

T. Troëng [a,c,*], **J. Malmstedt** [b], **M. Björck** [c]

[a] *Department of Surgery, Blekinge Hospital, S-371 85 Karlskrona, Sweden*
[b] *Department of Molecular Medicine and Surgery, Karolinska Institutet, Stockholm, Sweden*
[c] *Department of Surgical Sciences, Section of Vascular Surgery, Uppsala University Hospital, Uppsala, Sweden*

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Abstract *Objective:* To study external validity of the Swedvasc registry concerning numbers of procedures and mortality.
Materials and methods: Vascular registry data for carotid, infrainguinal bypass and aortic aneurysm (AAA) procedures were compared to the Swedish Hospital Discharge Register (SHDR) data, and the National Population Registry (for mortality) by matching every individual patient using the unique personal identity numbers (PINs). The time-period studied was 2000—2004 (5 years) for carotid and infrainguinal procedures. A separate analysis was performed for AAA-surgery in 2006.
Results: The external validity for carotid, infrainguinal bypass and AAA repair was 93.4%, 93.0% and 93.1%, respectively. The 30-day mortality was 0.86% after carotid and 2.9% after infrainguinal bypass procedures. Mortality was 2.6% after planned and 25.9% after unplanned AAA repair.
Although there was a general trend towards inferior outcomes after procedures not registered in the Swedvasc, those procedures were so few that in none of the analyses did the inclusion of non-registered procedures affect general outcomes significantly.
Combining data from both registries, the incidence for carotid, infrainguinal bypass and AAA procedures was 7.8, 15.2 and 13.6 per 100,000 person-years, respectively.
In the hospital-specific analysis for 2006 it was shown that the non-registered procedures for AAA were localized to one non-compliant county hospital, and small district hospitals not performing elective AAA-surgery but only rare emergency operations.
Conclusion: The external and internal validity of the Swedvasc registry allows to confidently assess volumes of, and mortality after, vascular surgery in Sweden.

* Corresponding author. T. Troëng, Department of Surgery, Blekinge Hospital, S-371 85 Karlskrona, Sweden. Tel.: +46 455734482.
E-mail address: thomas.troeng@ltblekinge.se (T. Troëng).

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Introduction

The extent, to which an observational study gives a true picture of vascular surgical care, depends on two fundamental properties, the external and the internal validity.

External validity concerns generalisability. If a sample is studied the issue is whether it is representative of the whole population. When coverage is incomplete a study may still have a high degree of validity if cases are missed at random and there is no systematic bias. If virtually all patients with a given disease or procedure in a well-defined population are registered, they will represent the true incidence or prevalence in a similar general population, since the data collection is almost complete. An independent source of data should be used to estimate the degree to which cases in question are registered. Usually a medical registry or study is validated against some administrative database. It should be noted, however, that in fact there is no ''gold standard''. Any method of registration or measurement will always miss some cases of those truly occurring. Thus the external validity of a registry is the extent (percentage) to which it records the sum of cases recorded by both (or more) methods.

Internal validity is the degree to which the study or registry is correct concerning data on patients actually included. Internal validity can be defined as the percentage of data fields that exactly match when compared from different sources or registration episodes. Re-registering of data from the primary medical records by an, preferably independent, observer or comparing with another source of data are different methods to study the internal validity. A national population registry with compulsory recording of deaths for legal purposes will secure a high internal validity concerning postoperative survival and fatal complications if record linkage to the registry is possible.

Previous studies found an 88.4—98.3% external validity for Swedvasc data. Internal validity was 93—99% for technical variables and 75—95% for medical risk factors.[1—14]

We have performed an external validation of Swedvasc at individual patient level by record linkage with the Swedish Hospital Discharge Register (SHDR) of the National Board of Health and Welfare (NBHW) and the National Population Registry (NPR). Unambiguous record linkage between all registers is possible through use of the unique personal identification number assigned to all Swedish residents.

The aim of this study is to assess the external validity of the Swedvasc registry for carotid and infrainguinal procedures and for abdominal aortic aneurysm repair (AAA). We also compared the mortality rates for registered and non-registered patients.

Materials and Methods

We compared all cases with procedure codes indicating carotid artery reconstruction, infrainguinal procedures or abdominal aneurysm repair identified in the Swedvasc registry and in the national SHDR database. Details on the Swedvasc registry are summarized in Fact Boxes 1 and 2, and on the other registries utilized for cross-matching in Fact Box 2.

Fact Box 1.

Sweden had 8,414,083 inhabitants in 1987 and 9,107,935 by 2006-11-01.
The Swedish Vascular Registry — Swedvasc

- started in 1987 and was nationwide by 1994
- has all 7 university vascular units, all 20 county hospitals and 5 district hospitals as active participants
- does not have the remaining 27 district hospitals as participants as they only occasionally perform vascular interventions
- registers around 10,000 open and endovascular arterial interventions annually
- had data on file for 159,144 procedures as per 2007-12-31.

All in-hospital episodes in Sweden are recorded in the SHDR with a delay of less than a year. Data include the patients' unique personal identification number (PIN, the date of birth combined with a unique four digit number, *i.e.* 19470102-0259), assigned to every Swedish citizen. This PIN is used extensively for administrative purposes to identify individuals in various public databases. Thus it is technically simple to find individuals in different databases and to combine data. The Swedvasc registry thus combines, after

Fact Box 2.

The Swedish Vascular Registry — Swedvasc
All arterial procedures are continuously reported to the national registry centre through the Internet. Patient, hospital and surgeon ID are included, as well as comorbidities, technical details of the procedure and outcome at 30 days and one year. Registration is performed by the responsible surgeon (or his colleagues performing the follow-up).
The Swedish Hospital Discharge Registry — SHDR
All in-patient episodes are reported annually from the counties to the National Board of Health and Welfare. Data include patient ID, hospital, department, dates of admission and of discharge, ICD-codes, possible procedure codes (if any) and discharge status. Reporting is based on the coding of diagnoses and procedures in the discharge records and is performed by secretarial staff at each county's administrative office.
The National Population Registry — NPR
Taxation authorities are responsible for the national registration of births and deaths in Sweden. According to law, death certificates signed by a physician should be sent to the taxation authorities the following workday. The population registry is continuously updated through the taxation office. In practice, any death verified is officially registered and date of death accessible within three weeks.

necessary permits are obtained, vascular registry data with possible dates of death from the NPR or with the SHDR.

The SHDR contains individually based information on inpatient care since 1964, with complete nationwide coverage since 1987. Each discharge record includes information on level of care at admission, diagnoses according to the International Classification of Diseases, up to 12 surgical procedures coded according to the Swedish version of NOMESCO Classification of Surgical Procedures (NCSP)[15] (see www.nordclass.uu.se/index_e.htm), dates for admission and discharge as well as discharge status. Personal identifier is complete in 99.3% of SHDR records and 98% of surgical procedures are coded correctly.[15,16] Unfortunately, SHDR does not contain information on comorbidities, indications for surgery or details of surgical technique. Furthermore, postoperative complications are also registered poorly. This is the rationale of having both the SHDR and the Swedvasc.

Each patient's first carotid procedure, infrainguinal bypass during the period 2000–2004 or first aortic aneurysm procedure repair during 2006 was identified in Swedvasc and in the SHDR. See Appendix 1 for details. Procedures for popliteal aneurysms were excluded (246 = 3.5% of all infrainguinal procedures) as this study focused on occlusive disease.

Although not of importance for the external validity, the frequency of missing values for registry variables concerning the procedures and years under study is shown in Appendix 2.

The Swedvasc files for carotid and bypass procedures and for AAA repairs were then matched with the corresponding SHDR files based on the PIN. Procedure date registered in Swedvasc was considered identical with that of the SHDR if it fell between admission and discharge dates recorded by SHDR. Both registries are linked to the NPR for accurate and official dates of death.

A separate validation was performed for AAA repairs in 2006 to demonstrate possible differences between centres.

The 95% confidence intervals (CIs) were calculated by the mid-P exact method according to Rothman KJ and Boice JD: Epidemiologic Analysis with a Programmable Calculator. NIH Pub. No. 79-1649, 1979, using the EpiSheet calculator at http://members.aol.com/krothman/modepi.htm.

Results

Carotid procedures

A total of 3589 (3526 open, 63 endovascular) patients with carotid procedures were identified during the period 2000–2004 in either of the registries. Swedvasc primarily identified 3340 (93.1%) and missed 249 of these and SHDR identified 3486 (97.1%) and missed 103. Among the 249 cases identified in SHDR only, 13 patients were subsequently found in Swedvasc although registered under different carotid procedure codes. Thus Swedvasc identified 3353 (3340 + 13) out of 3589 (93.4%) patients correctly. Exactly corresponding procedure codes were found in both registers for 3237 (90.2%) (Table 1).

One university hospital accounted for 124 (50%) of the procedures missed in Swedvasc. Only two of 21 centres registered fewer than 90% of their carotid procedures.

The 30-day mortality was 0.86% (95% CI 0.6–1.2%) for the entire group, with a higher mortality in the endovascular group (4.8%; 1.2–12.4%, 95% CI) compared to the open surgery group (0.8%; 0.6–1.1%, 95% CI). There were no statistically significant differences between registered and unregistered patients (Table 1).

Combining the Swedvasc data with the information from the SHDR gives an estimate of the incidence of carotid procedures in Sweden: 7.8 procedures per 100,000 person-years in 2000–2004.

Infrainguinal bypass procedures

A total of 6800 patients with infrainguinal bypass were identified during the period 2000–2004 in either of the registers. Swedvasc identified 6123 (90.0%) and missed 677 of these and SHDR identified 6480 (95.3%) and missed 320. Another 202 patients were found in Swedvasc, although registered under different procedure codes. Thus Swedvasc identified 6324 (6123 + 202) out of 6800 (93.0%) patients correctly. 5803 (85.3%) were found in both registers with exactly corresponding procedure code (Table 2).

Five hospitals (three non-participating) accounted for 165 (35%) of the procedures missed in Swedvasc. Only 5 of 33 centres performing at least 10 procedures per year registered fewer than 80% of their infrainguinal bypass procedures.

The 30-day mortality was 2.9% (95% CI 2.5–3.3%) for the entire group. There were no statistically significant differences between registered or unregistered patients (Table 2).

Combining the Swedvasc data with the information from the SHDR gives an estimate of the incidence of infrainguinal bypass procedures in Sweden: 15.2 procedures per 100,000 person-years in 2000–2004.

Aortic procedures

All procedures for abdominal aortic aneurysms in 2006 were identified in both registries. Matching for PIN and procedure code, identical data were found for 1025 individuals in the two registries. Another 128 individuals not registered by Swedvasc were identified with the relevant procedure codes and 96 of the individuals in the Swedvasc file could not be found in the SHDR (Table 3). Around one-third of those registered in only one of the registries had endovascular repair.

Out of the 128 cases from the SHDR not listed in Swedvasc for the selected procedure codes, 43 were subsequently identified in Swedvasc under other procedure codes. Thus only 85 individuals remained that were registered in the SHDR only. Consequently the Swedvasc registry recorded (1025 + 96 + 43)/1249 = 93.2% of procedures performed for AAA in Sweden in 2006.

The 30-day mortality for those registered by Swedvasc, and those not, is also seen in Table 3. There was no statistical difference for mortality within 30 days between the ''register groups'' compared to the mortality for the entire cohort for endovascular or planned open procedures. For open unplanned procedures, however, mortality for those missed by Swedvasc exceeded that of the entire cohort. Adding them to the whole group of unplanned open

Table 1 External validity of the Swedvasc registry for patients with carotid procedures in comparison with the SHDR during 2000–2004

Carotid	Matches	SHDR only	Swedvasc other code	Swedvasc only	Total	Proportion registered in Swedvasc[a] (%)
Open	3200	214	13	99	**3526**	**93.9**
Alive at 30 days	3175	211	13	99	**3498**	94.4
Dead at 30 days	25	3	0	0	**28**	89.3
Mortality 30 days (%)	**0.78**	**1.40**	**0.00**	**0.00**	**0.79**	
95% CI	0.5–1.1	0.4–3.8	–	–	0.6–1.1	
Endovascular	37	22	0	4	**63**	**65.1**
Alive at 30 days	34	22	0	4	**60**	63.3
Dead at 30 days	3	0	0	0	**3**	100.0
Mortality 30 days (%)	**8.11**	**0.00**	**0.00**	**0.00**	**4.76**	
95% CI	2.1–20.5	–	–	–	1.2–12.4	
All carotid	3237	236	13	103	**3589**	**93.4**
Alive at 30 days	3209	233	13	103	**3558**	93.5
Dead at 30 days	28	3	0	0	**31**	90.3
Mortality 30 days (%)	**0.86**	**1.27**	**0.00**	**0.00**	**0.86**	
95% CI	0.6–1.2	0.3–3.4	–	–	0.6–1.2	

Matching was performed individually by unique individual identity codes. Mortality according to the NPR (SHDR = Swedish Hospital Discharge Registry).

[a] Nominator is sum of matches, Swedvasc other code and Swedvasc only. Denominator is total number of procedures.

procedures increased its mortality from 26.5% (95% CI 21.9–31.3) to 29.7% (95% CI 25.1–34.3) which was not significant.

There was no mortality difference between open and endovascular technique for planned procedures. Mortality for unplanned procedures was approximately one-third for the endovascular technique compared to open surgery.

Table 4 shows a comparison between the mortality among cases registered by Swedvasc and the mortality of the whole cohort of all known aneurysm repairs. There was no statistical difference in any of the clinical subgroups, *i.e.* the confidence intervals for the differences all include zero.

University hospitals had performed 49.7% of all procedures and Swedvasc captured 94.2% (92.3–96.0%) of these, county hospitals had performed 44.8% of procedures and captured 88.3% (85.6–91.0%). One hospital was responsible for more than half of cases missed by county hospitals. District hospitals performed 5.5% of all procedures but had not reported four out of ten to the registry (Table 5).

Combining the Swedvasc data with the information from the SHDR gives an estimate of the incidence of abdominal aortic aneurysm repair in Sweden: 13.6 procedures per 100,000 person-years in 2006.

Discussion

This study of carotid, infrainguinal bypass, and AAA procedures is to our knowledge the first that has externally validated a national vascular registry on an individual patient basis based on unique identity codes. It shows that the Swedvasc registry has an external validity of 93.0% or more for these procedures.

Completely reliable information on death makes it possible to calculate mortality for registered and missed cases. Thirty-day mortality after carotid procedures of 0.86%, after infrainguinal bypass of 2.9%, after planned AAA

Table 2 External validity of the Swedvasc registry for patients with infrainguinal bypasses

Infrainguinal bypass	Matches	SHDR only	Swedvasc other code	Swedvasc only	Total	Proportion registered in Swedvasc[a] (%)
Bypass	5803	475	202	320	6800	**93.0**
Alive at 30 days	5638	455	196	312	6601	93.1
Dead at 30 days	165	20	6	8	199	97.0
Mortality 30 days (%)	**2.8**	**4.2**	**3.0**	**2.5**	**2.9**	
95% CI	2.4–3.3	2.7–6.3	1.2–6.1	1.2–4.7	**2.5–3.3**	

2000–2004 Matching was performed individually by unique individual identity codes. Mortality according to the NPR (SHDR = Swedish Hospital Discharge Registry).

[a] Nominator is sum of matches, Swedvasc other code and Swedvasc only. Denominator is total number of procedures.

Table 3 External validity of the Swedvasc registry for patients with abdominal aortic aneurysm repairs in comparison with the SHDR during 2006

	Matches	SHDR only	Swedvasc other code	Swedvasc only	Total	Proportion registered in Swedvasc[a] (%)
Planned open AAA procedure	354	18	13	25	**410**	95.6
Alive at 30 days	344	17	12	25	**398**	
Dead at 30 days	10	1	1	0	**12**	
Mortality 30 days (%)	2.8	5.6	7.7	0.0	**2.9**	
95% CI	1.4–5.0	0.3–24.5	0.4–32.5	–	**1.6–4.9**	
Planned AAA endovascular procedure	290	19	18	33	**360**	94.7
Alive at 30 days	285	17	17	33	**352**	
Dead at 30 days	5	2	1	0	**8**	
Mortality 30 days (%)	1.7	10.5	5.6	0.0	**2.2**	
95% CI	0.6–3.8	1.8–30.6	0.3–24.5	–	**1.0–4.2**	
Unplanned open AAA procedure	300	41	7	32	**380**	89.2
Alive at 30 days	225	18	4	20	**267**	
Dead at 30 days	75	23	3	12	**113**	
Mortality 30 days (%)	25.0	56.1	42.9	37.5	**29.7**	
95% CI	20.3–30.1	40.7–70.6	12.3–48.4	22.1–55.0	**25.3–34.5**	
Unplanned AAA endovascular procedure	81	7	5	6	**99**	92.9
Alive at 30 days	73	4	5	6	**88**	
Dead at 30 days	8	3	0	0	**11**	
Mortality 30 days (%)	9.9	42.9	0.0	0.00	**11.1**	
95% CI	4.7–17.9	12.3–78.4	–	–	**6.0–18.5**	
All AAA	1025	85	43	96	**1249**	93.2
Alive 12 at 30 days	927	56	38	84	**1105**	
Dead at 30 days	98	29	5	12	**144**	
Mortality 30 days (%)	9.6	34.1	11.6	12.5	**11.5**	
95% CI	7.9–11.5	24.6–44.7	4.4–23.9	7.0–20.3	**9.8–13.4**	

Matching was performed individually by unique individual identity codes. Mortality according to the NPR (SHDR = Swedish Hospital Discharge Registry).

[a] Nominator is sum of matches, Swedvasc other code and Swedvasc only. Denominator is total number of procedures.

Table 4 Difference between 30-day mortality in patients registered in Swedvasc and 30-day mortality in all patients with an abdominal aortic aneurysm repair found in the Swedvasc registry and/or the SHDR during 2006

	30-day mortality % (*N*)		Mortality difference % (95% CI)
	Registered in Swedvasc	All registered in Swedvasc and/or SHDR	
Planned open AAA procedure	2.8% (11/392)	2.9% (12/410)	−0.1% (−2.4 to 2.2)
Planned AAA endovascular procedure	1.8% (6/341)	2.2% (8/360)	−0.5% (−2.5 to 1.6)
Unplanned open AAA procedure	26.5% (90/339)	29.7% (113/380)	−3.2% (−9.8 to 3.4)
Unplanned AAA endovascular procedure	8.7% (8/92)	11.1% (11/99)	−2.4% (−10.9 to 6.0)
All AAA	9.9% (115/1164)	11.5% (144/1249)	−1.6% (−4.1 to 0.8)

Matching was performed individually by unique individual identity codes. Mortality according to the NPR (SHDR = Swedish Hospital Discharge Registry).

Table 5 External validity for individual hospitals of the Swedvasc registry for patients with AAA procedures in 2006

	Matches	SHDR only	Swedvasc only	Total	Proportion registered in Swedvasc[a] (%)
U1	91	7	5	103	93.2
U2	59	3	3	65	95.4
U3	55	0	5	60	100.0
U4	133	12	8	153	92.2
U5	82	9	11	102	91.2
U6	64	2	3	69	97.1
U7	51	3	9	63	95.2
Sum University	**535**	**36**	**44**	**615**	**94.1**
C1	69	2	5	76	97.4
C2	3	1	0	4	75.0
C3	23	0	3	26	100.0
C4	8	1	0	9	88.9
C5	7	2	1	10	80.0
C6	10	2	0	12	83.3
C7	24	1	3	28	96.4
C8	13	1	0	14	92.9
C9	42	1	1	44	97.7
C10	4	1	11	16	93.8
C11	27	2	1	30	93.3
C12	23	0	5	28	100.0
C13	12	0	1	13	100.0
C14	29	5	4	38	86.8
C15	34	5	3	42	88.1
C16	40	5	4	49	89.8
C17	6	35	1	42	16.7
C18	26	0	0	26	100.0
C19	16	1	0	17	94.1
C20	26	0	5	31	100.0
Sum County	**442**	**65**	**48**	**555**	**88.3**
D1	11	0	1	12	100.0
D2	2	3	0	5	40.0
D3	0	1	0	1	0.0
D4	7	2	1	10	80.0
D5	1	1	0	2	50.0
D7	0	1	0	1	0.0
D8	0	6	0	6	0.0
D9	17	3	2	22	86.4
D10	0	2	0	2	0.0
D11	0	1	0	1	0.0
D12	0	7	0	7	0.0
Sum District	**38**	**27**	**4**	**69**	**60.9**
All	**1015**	**128**	**96**	**1239**	**89.7**

U = university hospital, C = county hospital, D = district hospital.

[a] Nominator is sum of matches and Swedvasc only. Denominator is total number of procedures.

repair of 2.6% and after unplanned AAA repair of 25.9% compares favourably with contemporary reports.[17–22]

There was no difference in mortality between registered and non-registered patients, except for unplanned open AAA repairs. The small group of patients operated on for emergent AAA repair and not registered was biased by the fact that many of these repairs were performed in small district hospitals not participating in the registry, performing only occasional operations on unstable patients. However, since the non-registered procedures were so few, this lack of difference is probably a type-II statistical error. Trends towards inferior results after procedures not registered were noted in all results (Tables 1–3), consistent with previous investigations reporting on validity and outcomes.[11,19–21] A basic purpose of clinical registries is to provide valid data on population estimates of outcomes. It is gratifying that mortality for all known aortic aneurysm repairs did not differ statistically from those registered in Swedvasc only (Table 4).

Few centres demonstrated low compliance while the majority had high registration rates. This is also true when specific procedures are studied. In this study one county hospital (Table 5, C17) reported only 17% of its procedures for AAA in 2006. It was explained by a temporary lack of staff, and the situation was normalised during 2007. If this non-compliant hospital, and the small district hospitals not performing elective AAA-surgery are excluded from the analysis the overall registration rate increases from 89.7% to 94.1%. Thus a single non-compliant hospital may jeopardise the excellence of a national registry.

An RCT has high internal validity but often a questionable external validity. Many hospitals recruiting patients randomise less than 10% of eligible patients, raising questions about the generalisability of the results. Many of the RCTs that we base our clinical decision-making on did not even report on non-randomised patients.[23] Data from population-based registries have an advantage in this respect, but they are highly dependent on the external and internal validity of data.

Other vascular registries report variable validities. Finnvasc[14] (Finland) reported an external validity of 81% (range 53–100%) when compared to hospital records. In a recent publication, the regional registry of Helsinki was externally validated against the discharge registry concerning carotid TEA, with excellent results.[24]

The Danish Vascular Registry[18] checked internal validity by re-registration finding 90% agreement on procedure codes and indications.

In Norway the external validity of carotid endarterectomies[20] and abdominal aortic aneurysm repairs[19] was 84% and 69% respectively. No PIN is part of the central vascular registry nor of the national administrative patient registry.

The National Vascular Database (NVD) in the United Kingdom registers carotid endarterectomies, aortic aneurysm repairs and infrainguinal bypasses since 1998. The NVD has no PIN. External validity was studied by procedure code and centre comparison with the national Hospital Episode Statistics (HES).[21]

The NVD registered only 26% of index procedures recorded in the HES, and 50% of procedures recorded by HES in centres known to participate in the NVD. Individual consultants known to participate registered 90% of

procedures for AAAs, 84% of carotid endarterectomies and 65% of infrainguinal bypasses.

Thus, both NORKAR and NVD described a significant proportion of non-registered procedures.

A regional vascular registry in nine hospitals in New England adopted similar inclusion criteria as the British registry.[22] Social Security Number as unique identifier made matching by individual patients possible. The vascular registry primarily incorporated 91.7% of eligible cases compared to hospital administrative data. Definitive in-hospital AAA mortality was 34% (range 19—50) for ruptured aneurysms and 2.9% (range 0—5.9) for elective open repairs.

The Swedvasc has been effective for 20 years and is nationwide since 1994. All centres performing vascular procedures, open and endovascular, report to the registry. Surgeons meet annually to discuss results and further development. Hospital-specific outcome data are made public annually since 2004. In assessing the external validity of a vascular registry Sweden has the advantage of a unique PIN for all citizens, linkage with a population registry that includes dates of death and comparison with a nationwide hospital in-patient registry with universal coverage and high quality.[25]

The external validity of Swedvasc for *carotid procedures* in previous studies was 94—95.9%.[8—10] They revealed only occasional cases of missed neurological complications, which together with an accurate death rate safeguards a high degree of internal validity. Thus the comparably low combined stroke and death rate of 3—4% after carotid endarterectomy in Sweden is credible and encouraging.

The early validation study of *infrainguinal revascularization* by Elfström et al.[11] showed that adding the missed cases to the registered ones did not significantly change amputation or death rates in any of the examined centres. In a more recent study of the internal validity for leg artery revascularisation Malmstedt et al.[12] found an accuracy of >90% for most variables and noted that most missing values were caused by few centres, whereas most cases were carefully registered.

Abdominal aortic aneurysm repair is performed to prevent premature death from aneurysm rupture, validity of mortality being crucial. Cases missed by a registry may imply unknown deaths, a result of deficient external validity. Reliable data on the possible date of death for all operated cases enabled Wanhainen et al.[14] to convincingly report declining perioperative mortality in Swedish aneurysm repair over the last decade.

Appendix 1

Procedures were defined as any NOMESCO code[15] equal to carotid procedures (open: 'PAF2#', 'PAN2#', 'PAK2#' and endovascular: 'PAP2#', 'PAQ2#'), infrainguinal bypass ('PEH##', 'PFH##') (# denotes any number), open AAA repair ('*PDG10*', '*PDG20*', '*PDG21*', '*PDG22*', '*PDG23*', '*PDG24*', '*PDG35*', '*PDG99*') or endovascular AAA repair ('*PDQ10*', '*PDQ21*', '*PCQ10*'). The NOMESCO code defines operative procedures, both open and endovascular, and is common for the Nordic countries.

Appendix 2

Missing values/not known for certain variables in Swedvasc for the categories and years studied, percent

	Carotid procedure	Infrainguinal bypass		AAA	AAA
		Claudication	Critical ischaemia	Elective	Emergency
Indication for surgery	0	0	0	0	0
Cerebrovascular disease	2.8	10.5	8.2	12.2	7.2
Diabetes	6.2	9.7	6.6	13.2	5.8
Heart disease	5.0	8.9	6.0	9.3	6.7
Hypertension	4.9	8.4	8.7	9.7	10.0
Pulmonary disease	6.5	11.3	8.8	12.6	7.2
Renal insufficiency	7.1	11.7	9.1	12.2	9.7
Previous vascular surgery	6.1	6.2	5.7	11.7	4.2
Smoking	11.2	9.1	13.6	12.2	38.8
ASA classification	38.6	41.0	38.7	22.4	10.4
Surgical/endovascular technique					
Type of procedure	0.3	0	0	0.9	1.7
Type of graft	6.7	2.0	2.5	0.6	1.1
Surgical complication	0.8	0.6	1.2	6.1	7.2
General complication	0.9	1.0	1.5	6.2	7.5

Conclusion

The external validity of Swedvasc for the three core vascular surgical procedures carotid, infrainguinal and abdominal aortic aneurysm reconstructions is 93.4%, 93.0% and 93.1% respectively. We conclude that the Swedish Vascular Registry — Swedvasc can confidently assess volumes of, and mortality after, vascular surgery in Sweden.

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