Supplementary Appendix: Coding algorithm

Our initial coding algorithm to define reintervention events after EVAR included 42 ICD-9 diagnosis codes and 24 ICD-9 procedure codes (Supplementary Table 1). We defined a reintervention event in Medicare claims as any patient having one of these billing codes appear in their Medicare claims file after their index procedure. We allowed either an ICD-9 diagnosis code (which was the primary diagnosis code for the admission) or an ICD-9 procedure code to represent a reintervention event. These were not considered mutually exclusive, so that an ICD-9 primary diagnosis code also found with an ICD-9 procedure code during the same admission was considered a single reintervention event. Although it included subcodes which were not specific to vascular procedures, we felt it important to initially include procedure code 9966.x to capture potentially miscoded events. Code 9957 was included for a similar reason.

Using the original coding algorithm, the VQI-Medicare linked data identified 65 events during the first year following EVAR (Supplementary Table 3). We then compared the VQI-Medicare identified events with the reintervention events found on chart review. We conducted telephone interviews if the clinical outcome could not be adequately determined on chart review. If a patient died during a hospital admission at another institution and that admission was connected with one of the billing codes in our algorithm, we assumed that the death was aneurysm-related and associated with an attempted reintervention. This was done to provide the most conservative estimate of events. While we considered records from all hospitals that had been entered into the patients available medical record, we did not visit outside institutions to perform additional chart reviews. We did not attempt telephone interviews to assess for reintervention events in deceased patients.

Billing codes with an accuracy lower than 50% were considered for removal from the coding algorithm (Supplementary Table 2). For example, procedure code 3893 was associated with a true clinical reintervention event in 1 of 21 cases, this code was therefore removed from our list of codes chosen to represent a reintervention event. If a code only appeared once, however, we did not feel that this provided adequate information to remove it from the algorithm. Therefore, codes only appearing once, even if not associated with a clinical event, were kept in the algorithm. We also removed codes with 50% accuracy that were associated with another code that consistently performed well. For example, diagnosis code 44422 was associated with a true reintervention event in 1 of 2 cases. However, that reintervention event was also associated with procedure code 3929, a code which was associated a true event in 5/5 cases. We therefore removed diagnosis code 44422 from the coding algorithm. The rate of reintervention using the VQI-Medicare data was then recalculated using the revised list of billing codes.

Supplementary Table 1: Codes used to identify reintervention after EVAR: Baseline coding algorithm.

Code	Definition
ICD-9 Procedure codes	
3804	incision of vessel, aorta
3806	incision of vessel, abdominal artery
3808	incision of vessel, lower limb artery
3814	endarterectomy of aorta
3816	endarterectomy of abdominal arteries
3818	endarterectomy of lower limb arteries
3834	resection of vessel with anastomosis
3838	resection of lower limb arteries w/anastomosis
3844	resection of abdominal aorta w/replacement
3846	resection of abdominal arteries w/replacement
3848	resection of lower limb arteries w/replacement
3864	other excision of vessels, aorta, abdominal
3866	other excision of abdominal arteries
3868	other excision of lower limb arteries
3884	other surgical occlusion of abdominal aorta
3886	other surgical occlusion of abdominal arteries
3888	other surgical occlusion of lower limb arteries
3891	arterial catheterization
3893	venous catheterization not elsewhere classified
3925	aorta-iliac-femoral bypass
3926	other intra-abdominal vascular shunt or bypass
3929	other (peripheral) vascular shunt or bypass
3930	suture of unspecified blood vessel
3931	suture of artery

3950   angioplasty/atherectomyo of other non-coronary vessel(s)

3951   clipping of aneurysm

3952   other repair of aneurysm

3954   re-entry operation (aorta)

3956   repair of blood vessel w/tissue patch graft

3957   repair of blood vessel w/synthetic patch graft

3958   repair blood vessel w/unspecified type patch graft

3959   other repair of vessel

3971   endovascular implantation graft abdominal aorta

3972   endovascular repair/occlusion head & neck vessels

3973   endovascular implantation graft thoracic aorta

3974   endovascular removal obstruction head & neck vessels

3975   endovascular embolization or occlusion

3976   endovascular embolization or occlusion

3977   temporary treatment endovascular occlusion vessel

3978   endovascular implant aortic branch graft

3979   other endovascular repair of other vessels

3990   insertion non-drug-eluting peripheral vessel stents

ICD-9 Diagnosis codes

4413   abdominal aortic aneurysm, ruptured

4415   aortic aneurysm of unspecified site, ruptured

4400   atherosclerosis of aorta

4442   embolism & thrombosis arteries of the extremities

44421   embolism & thrombosis arteries upper extremity

44422   embolism & thrombosis arteries lower extremity

4448   embolism & thrombosis of other specified artery

44481   embolism & thrombosis of iliac artery

44489   embolism & thrombosis of other specified artery

9957   other adverse food reactions, other

9961	mechanical complications other vascular device implant & graft
99659	mechanical complication due to other implant and internal device, not elsewhere classified
9966	infection &inflammatory reaction due to internal prosthetic device implant &graft
99660	infection &inflammatory reaction due to unspecified device implant & graft
99661	infection &inflammatory reaction due to cardiac device implant & graft
99662	infection &inflammatory reaction due to other vascular device implant & graft
99663	infection &inflammatory reaction due to nervous system device implant & graft
99664	infection &inflammatory reaction due to indwelling urinary catheter
99665	infection &inflammatory reaction due to other genitourinary device implant & graft
99666	infection &inflammatory reaction due to internal joint prosthesis
99667	infection & inflammatory reaction due to other internal orthopedic device implant & graft
99668	infection &inflammatory reaction due to peritoneal dialysis catheter
99669	infection &inflammatory reaction due to other internal prosthetic device implant &graft
99674	other complications due to other vascular device implant & graft

Legend: EVAR, endovascular aneurysm repair; ICD-9, international classification of diseases, ninth revision.

Supplementary Table 2: Changes to the coding algorithm based on chart review.

Code	Definition	Chart review events	Times appearing	Decision	Justification
Diagnosis codes					
4400	atherosclerosis of aorta	0	1	Keep	Appeared once
4413	abdominal aortic aneurysm, ruptured	1	3	Keep	Add modifier, drop if days to event <1
9961	mechanical complications due to other vascular device implant & graft	17	17	Keep	Correct all times
44422	Embolism & thrombosis arteries, lower extremity	1	2	Drop	Correct only when found with 3929
99669	Infection & inflammation reaction due to other internal prosthetic device implant & graft	1	1	Keep	Appeared once
99674	other complications due to other vascular device implant & graft	7	7	Keep	Correct all times
Procedure codes					
3806	incision of vessel, abdominal artery	1	1	Keep	Appeared once
3818	endarterectomy of lower limb arteries	1	1	Keep	Appeared once
3834	resection of vessel with anastomosis	0	1	Keep	Appeared once
3848	resection of lower limb arteries w/replacement	0	2	Drop	Incorrect both times
3893	venous catheterization not elsewhere classified	1	21	Drop	Correct once when found with 99612
3929	other (peripheral) vascular shunt or bypass	5	5	Keep	Correct all times
3950	Angioplasty/atherectomy non-coronary vessel(s)	3	8	Drop	Correct when found with 9961, 99674 in two of the cases
3952	other repair of aneurysm	0	1	Keep	Appeared once
3971	endovascular implantation of graft abdominal aorta	7	8	Keep	Correct in most cases
3973	endovascular implantation of graft thoracic aorta	0	2	Drop	Incorrect both times
3979	other endovascular repair of other vessels	6	6	Keep	Correct all times

Supplementary Table 3: Reintervention events occurring within the first year in Medicare: Baseline coding algorithm.

Diagnosis code	Procedure code	Clinical event	Chart review event	Found in VQI
9961	3979	EVAR limb extension	Yes	Yes
9961		Proximal aortic cuff	Yes	Yes
9961	3971	Proximal aortic cuff	Yes	Yes
99674	3929	Femoral-femoral bypass for EVAR limb occlusion	Yes	Yes
	3971	Proximal aortic cuff and renal stent implantation	Yes	Yes
9961	3979	Translumbar coiling of endoleak	Yes	Yes
9961		EVAR limb thrombectomy	Yes	Yes
	3950	EVAR limb distal extension	Yes	Yes
9961	3971	Proximal aortic cuff	Yes	Yes
99674	3929	Femoral-femoral bypass for EVAR limb occlusion	Yes	Yes
9961	3971	Proximal aortic cuff and renal stent	Yes	Yes
9961	3979	Transcaval coiling of endoleak	Yes	Yes
99674	3979	EVAR limb thrombectomy and complete relining of EVAR	Yes	No
9961	3971	Proximal aortic cuff	Yes	No
9961	3971	Proximal aortic cuff	Yes	No
9961	3979	Transfemoral coiling of endoleak	Yes	No
9961	3893	Attempted transcaval coiling of endoleak	Yes	No
99674	3979	EVAR limb thrombectomy	Yes	No
99674	3929	Fememoral-femoral bypass for EVAR limb occlusion	Yes	No
9961		Attempted recanalization of renal chimney	Yes	No
9961	3971	Proximal aortic cuff	Yes	No
99674	3806	EVAR limb thrombectomy	Yes	No
9961		Attempted coiling of endoleak	Yes	No
9961	3950	Repair of kinked EVAR	Yes	No

99674	3950	Reconstruction for exposed AUI and femoral-femoral bypass	Yes	No
44422	3929	Femoral-femoral bypass for EVAR limb occlusion	Yes	No
	3818	Femoral reconstruction for new short distance claudication after percutaneous EVAR	Yes	No
9961		Deceased at outside hospital, unknown cause	Yes	No
	3929	Deceased at outside hospital, unknown cause	Yes	No
4413		Deceased at outside hospital, unknown cause	Yes	No
4413	3834	No reintervention, no rupture	No	No
44422	3848	Popliteal aneurysm repair	No	No
	3848	Popliteal aneurysm repair	No	No
	3893	Tunneled dialysis catheter placement	No	No
	3893	PICC line placement	No	No
	3893	PICC line placement	No	No
	3893	PICC line placement	No	No
	3893	LTF	No	No
	3893	No reintervention, no rupture	No	No
	3893	PICC line placement	No	No
	3893	LTF	No	No
	3893	No reintervention, no rupture	No	No
	3893	ICD and pacemaker placement	No	No
	3893	LTF	No	No
	3893	LTF	No	No
	3893	Central line placement	No	No
	3893	No reintervention, no rupture	No	No
	3893	No reintervention, no rupture	No	No
	3893	Central line placement	No	No
	3893	No reintervention, no rupture	No	No
	3893	Temporary pacer wire placement	No	No
	3893	Central line placement	No	No

	3893	Groin lymphocele, non-operative management	No	No
	3950	No reintervention, no rupture	No	No
	3950	Renal artery stent	No	No
	3950	No reintervention, no rupture	No	No
	3950	No reintervention, no rupture	No	No
	3950	Revisions to a peripheral bypass graft	No	No
	3952	No reintervention, no rupture	No	No
	3971	No reintervention, no rupture	No	No
	3973	Ruptured thoracic aortic aneurysm	No	No
	3973	TEVAR	No	No
4400		Coronary stent	No	No
4413		No reintervention, index repair for rupture	No	No
99669		No reintervention, no rupture	No	No

Legend: EVAR, endovascular aneurysm repair; PICC, peripherally inserted central catheter; LTF, lost to follow up; ICD, implantable cardioverter defibrillator; TEVAR, thoracic endovascular aneurysm repair.