

Physiological POSSUM as an Indicator for Long-term Survival in Vascular Surgery

I. Sohail ^{a,†}, L. Jonker ^{b,†}, A. Stanton ^a, M. Walker ^a, T. Joseph ^{b,*}

^aNorth Cumbria University Hospitals NHS Trust, West Cumberland Hospital, Whitehaven, UK

^bNorth Cumbria University Hospitals NHS Trust, Cumberland Infirmary, Newtown Road, Carlisle CA2 7HY, UK

WHAT THIS PAPER ADDS

This study showed that the POSSUM physiology score (PPS) can be used as an indicator of long-term survival of vascular surgery patients. In addition, stratification of low- and high-risk patients showed a statistically significant difference in all-cause mortality outcomes (median 17 months survival for high-risk patients versus 70 months for low-risk patients). These two newly identified characteristics of PPS in vascular patients should be of value for surgical management.

Objectives: We investigated whether the POSSUM physiology score, originally designed as an indicator for 30-day mortality for comparative audit, could be used as an indicator of long-term survival in vascular surgery practice.

Methods: Data from 184 different vascular procedures conducted between 1989 and 2000, containing survival data for each patient of 10 years or longer, were analysed retrospectively. Parameters collected were the pre-operative physiological and the operative severity POSSUM score, gender, and type of procedure. Multivariate analyses were performed using Cox regression method and, on the basis of their physiological POSSUM score grouping, Kaplan–Meier analysis was performed for estimation of overall survival.

Results: Both an increase in physiological POSSUM score (hazard ratio [HR] 1.050, 95% confidence interval [CI] 1.031 to 1.070) and one of its components, age (HR 1.025, 95% CI 1.006 to 1.045; $p = 0.009$), were shown to be indicators of long-term all-cause mortality. The sample's mean physiological POSSUM score of 21 was then used as a cut-off point to categorise low and high-risk vascular surgery patients. Median survival in the low-risk group was 70 months (95% CI 56–86 months), whereas in the high-risk group this was 17 months (95% CI 3–31 months).

Conclusion: The physiological POSSUM score, including patient age, is an indicator of long-term survival of patients with vascular disease. This may help in choosing the appropriate vascular intervention.

© 2013 European Society for Vascular Surgery. Published by Elsevier Ltd. All rights reserved.

Article history: Received 25 February 2013, Accepted 23 May 2013, Available online 24 June 2013

Keywords: Mortality, Survival, POSSUM, Vascular, Surgery, Patient fitness

INTRODUCTION

The physiological and operative severity score for enumeration of mortality and morbidity (POSSUM) is a scoring system that allows prediction of perioperative mortality and morbidity in general surgical patients.¹ POSSUM was originally developed for comparative audit purposes.^{2,3} A number of similar risk-scoring tools have been devised and evaluated over the years, with POSSUM consistently performing well when used for vascular

surgery patients.⁴ Subsequent observations on orthopaedic and colorectal cancer patients demonstrated that POSSUM also predicted long-term overall survival.^{5,6} The BASIL trial suggested that an endovascular-first approach would suit vascular patients with short life expectancy whereas a bypass-first approach would be of benefit in patients who were going to live longer.⁷ An endovascular-first approach may be advisable in patients with significant comorbidity, whereas for fit patients with a longer-term perspective a bypass procedure may be offered as a first-line interventional treatment.⁸

A system to predict long-term survival could potentially guide vascular surgeons to tailor treatments better to patients of different risk categories. This may apply to aneurysm management as well due to the differences in durability of the two approaches, with endovascular surgery requiring more secondary interventions in the long term.^{9,10} The primary objective of this study was therefore to evaluate any potential relation between the POSSUM score

* Corresponding author. North Cumbria University Hospitals NHS Trust, Cumberland Infirmary, Newtown Road, Carlisle CA2 7HY, UK.

E-mail address: thomas.joseph@ncuh.nhs.uk (T. Joseph).

† These authors contributed equally to this work.

1078-5884/\$ — see front matter © 2013 European Society for Vascular Surgery. Published by Elsevier Ltd. All rights reserved.

<http://dx.doi.org/10.1016/j.ejvs.2013.05.018>

Table 1. Types of vascular surgery performed.

Surgical procedure category	Patients, n (%)
Femoropopliteal bypass	47 (26%)
Other femoral surgery	40 (22%)
Endarterectomy	26 (14%)
Other amputations	16 (9%)
Embolectomy	15 (8%)
Below knee amputation	13 (7%)
Sympathectomy	11 (6%)
Above knee amputation	8 (4%)
Angioplasty	5 (3%)
Aortic aneurysm repair	3 (2%)

prior to operation and long-term overall survival of patients with vascular disease.

METHODS

POSSUM scoring system

The POSSUM scoring system was developed in the late 1980s from the need for a simple scoring system that could be used across the general surgical spectrum to compare the outcomes between different units. At the outset the developers started with 62 variables from standard surgical practice and analysed their relevance by multivariate analysis. Point value on an exponential score (1, 2, 4 or 8) was assigned after dividing the multivariate discriminant function coefficients of the relevant factors by a constant, and rounding them to the nearest whole number. Of the original variables, the 12 final clinical features that are scored for the POSSUM physiology score (PPS) are age, cardiac signs, chest radiograph, respiratory signs, systolic blood pressure, pulse rate, coma score, serum urea/Na/K, haemoglobin level, white blood cell count, and electrocardiogram (total score range is 12–96).¹ The components of the operative severity POSSUM (OSP) score include magnitude, number of operations within 30 days, intraoperative blood loss, contamination, presence of malignancy, and timing of operation (total score range is 6–48).¹ Since its introduction in the early 1990s, various groups have sought to further optimise POSSUM and to tailor it to specific disease areas, including vascular surgery.¹¹ However, the original generic POSSUM is probably still the tool that is in widest use, is relevant to vascular surgery,¹² and was therefore an appropriate tool to evaluate in relation to long-term overall survival.

Patients

A total of 184 vascular patients operated between 1989 and 2000 in our district general hospital had their physiological parameters prospectively collected using a pro forma; A retrospective study was conducted on the anonymised data. Data collected as part of the analysis included patient age and gender, PPS, OSP score (for 160 out of 184 patients), date and type of operation, follow-up period and alive/deceased status up to 31 December 2009.

Statistical analysis

Data were collated in Microsoft Excel 2007, and further analysed and interpreted using SPSS Statistical Package for Social Sciences (SPSS) version 17.0 (SPSS Inc. Chicago, IL, USA, 2007). Cox multivariate and univariate regression analysis and Spearman correlation coefficient analysis were performed for the complete sample, whereas Kaplan–Meier survival curves, log-rank test (survival) and Student *t*-test (age) were applied to the low and high PPS groups.

RESULTS

The average age for the 184 patients at their first operation, that is start of data recording, was 71 years, with a median of 72 years (minimum age 44 years and maximum age 93 years). Males accounted for 61% of the cohort, and 39% were females. The longest follow-up for one of the patients was 246 months, whereas the mean follow-up for all patients was 60 months (median 42 months). Twenty of the 184 patients, 11%, were alive on the last follow-up date, which was 31 December 2009. Table 1 shows a summary of the procedures these patients underwent. Bypass surgery and amputations were the most common among them.

The relationship between age, PPS, OSP score, gender and amputation status were first investigated by Cox multivariate regression analysis. Neither patient gender nor operations involving amputations had a statistically significant impact on long-term all-cause mortality in this sample; only amputation was significantly associated with all-cause mortality in univariate regression analysis. Increased age and PPS correlated with increased all-cause mortality; conversely, a higher OSP score correlated with decreased long-term all-cause mortality (Table 2). Univariate correlation analysis confirmed the data obtained in Cox regression analysis. There was significant inverse correlation between PPS and survival time, indicating that an increased PPS

Table 2. Cox multivariate and univariate regression analysis of patient survival.

Variable	Multivariate		Univariate	
	Hazard ratio (95% CI)	<i>p</i> -Value	Hazard ratio (95% CI)	<i>p</i> -Value
Age	1.025 (1.006 to 1.045)	0.009	1.040 (1.022 to 1.057)	<0.001
PPS	1.050 (1.031 to 1.070)	<0.001	1.059 (1.043 to 1.075)	<0.001
OSP score	0.937 (0.881 to 0.996)	0.037	0.931 (0.879 to 0.986)	0.015
Gender	1.072 (0.759 to 1.513)	0.693	1.118 (0.869 to 1.626)	0.281
Amputation status	0.866 (0.547 to 1.371)	0.540	1.664 (1.111 to 2.492)	0.014

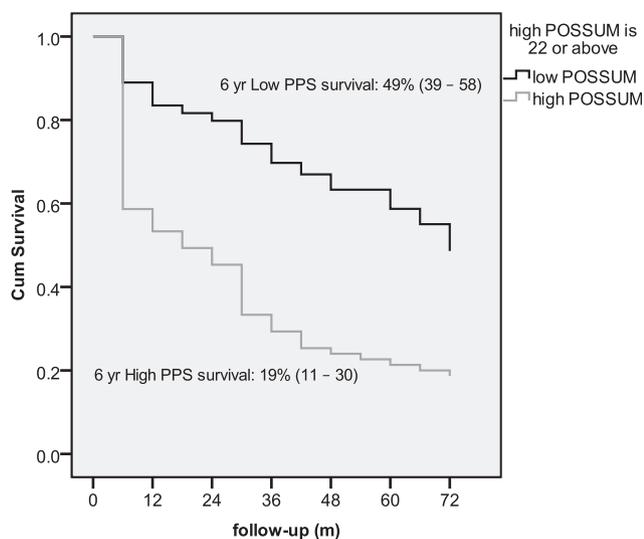
CI = confidence interval.

Table 3. Number of patients with low and high POSSUM physiological score and survival rates.

	Patients, <i>n</i>	Age in yrs, mean	Deceased, <i>n</i> (%)	Alive, <i>n</i> (%)	Median survival (months)	Survival 95% CI (months)
Low PPS	109	68	92 (84%)	17 (16%)	70	56 to 86
High PPS	75	71	72 (96%)	3 (4%)	17	3 to 31
Overall	184	71	164 (89%)	20 (11%)	40	25 to 55

increased the mortality. The Spearman's rho correlation coefficient was -0.508 ($p < 0.001$). In comparison, age by itself also correlated with survival, but to a lesser degree than PPS. The Spearman rho correlation coefficient for age was -0.323 ($p < 0.001$). OSP score on the other hand, correlated positively with survival albeit very moderately (Spearman rho 0.053 , $p < 0.001$).

The mean PPS for the cohort was 21.45; therefore a score of 21 was taken as the cut-off point between low- (up to and including 21) and high-risk (22 and above) vascular surgery patients. On average, the patients in the low PPS group were significantly younger than those in the high PPS group, mean 68 years versus 71 years (t -test $p < 0.001$), see Table 3. This equates to a point score difference of 2 when using PPS. The survival times also differed significantly (log-rank test, $p < 0.001$) between the low- and high-risk patients. Median difference in survival time was 53 months, and 95% of all high-risk patients do not survive beyond 31 months. Only 3 out of 75 (4%) patients survived this follow-up period; these high-risk patients were followed up for 130, 136 and 140 months respectively. Fig. 1 shows a Kaplan–Meier survival analysis for all patients, stratified by low- and high-risk PPS. The observed effect was consistent whether one included 30-day mortality or not, but the illustration shows the result with all mortality included. The survival curves start to converge at 100 months but are particularly different at month 50.



Numbers at risk							
Low PPS	109	91	87	76	69	64	53
High PPS	75	40	34	22	18	16	14

Figure 1. POSSUM score and relationship with survival of patients.

DISCUSSION

This study shows that a vascular patient's pre-operative condition, measured by PPS, can predict their overall survival. On the other hand, a very limited positive, probably non-attributable, correlation was found between OSP score and long-term overall survival. Similar observations were made by Back et al. in 2004.¹³ Age is a parameter in PPS and is already known to be a risk factor for mortality within 30 days of vascular surgery, for example in aortic procedures, and has also been shown to be an independent risk factor for long-term mortality in vascular surgery.^{13,14} In this study, however, the higher correlation coefficient for PPS than for age indicates that PPS has a stronger correlation with long-term overall survival of patients. The correlation between cardiac status and survival has already been shown.¹³ The reason for convergence of the Kaplan Meier curves at 100 months is not clear but may reflect the changing physiology with time. Stratification of the PPS into a low- and high-risk group of patients to compare the long-term overall survival has been applied previously for colorectal cancer patients and orthopaedic patients.^{5,6} Brosens et al.⁵ also used the mean PPS, without the age component, to discriminate between low- and high-risk groups. The clinical parameters included in PPS are routinely collected in everyday practice and were considered to be easy to use for even the non-specialists.¹ Our cohort of patients included a variety of vascular conditions reflecting the spectrum of conditions usually met in vascular practice. Therefore we believe that the above finding may potentially help vascular surgical practice in general.

The expansion of endovascular devices and imaging capabilities has opened a variety of new minimally invasive techniques to treat vascular patients. The BASIL trial looked at endovascular-first and surgery-first strategies and concluded that there was no significant difference between the two strategies in terms of overall survival or amputation-free survival except in patients who survived beyond 2 years after the intervention.^{14,15} For those patients who survived for at least 2 years after randomisation, a bypass-first revascularisation strategy was associated with a significant increase in subsequent overall survival and a trend towards improved amputation-free survival.^{14,15} This finding started the quest to find a predictor for survival in vascular patients, and this has been shown to have cost implications too.^{16,17} A recent critical appraisal suggested that any thoughtful review of the available data leads one to the conclusion that neither an "endo-first" nor a "bypass-first" dogma is an appropriate technique in patients with critical limb ischaemia.¹⁸ Management of abdominal aortic aneurysms also faces similar issues.

Since its introduction in the early 1990s,¹ various groups have sought to further optimise POSSUM and to tailor it to specific specialty areas, including vascular surgery.¹¹ However, the original generic POSSUM is probably still the tool that is in widest use and is relevant to vascular surgery.¹² The scoring is simple and uses only routine parameters, making it easier for daily practice to guide vascular surgeons to tailor the treatment options to patients of different categories. In conclusion, this study shows that the PPS, rather than the OSP score, can potentially be used as an indicator of a patient's long-term survival. As a component of PPS, age contributes to this too. PPS can therefore play a role when risk-stratifying a patient as part of their surgical management.

ACKNOWLEDGEMENTS

We are grateful to the team members of the vascular surgery department for recording and collecting the data.

CONFLICT OF INTEREST

None.

FUNDING

None.

REFERENCES

- Copeland GP, Jones D, Walters M. POSSUM: a scoring system for surgical audit. *Br J Surg* 1991;**78**:355–60.
- Copeland GP, Jones D, Wilcox A, Harris PL. Comparative vascular audit using the POSSUM scoring system. *Ann R Coll Surg Engl* 1993;**75**:175–7.
- Mosquera D, Chiang N, Gibberd R. Evaluation of surgical performance using V-POSSUM risk-adjusted mortality rates. *ANZ J Surg* 2008;**78**:535–9.
- Neary WD, Crow P, Foy C, Prytherch D, Heather BP, Earnshaw JJ. Comparison of POSSUM scoring and the Hardman Index in selection of patients for repair of ruptured abdominal aortic aneurysm. *Br J Surg* 2003;**90**:421–5.
- Brosens RP, Oomen JL, Glas AS, Bochove A, Cuesta MA, Engel AF. POSSUM predicts decreased overall survival in curative resection for colorectal cancer. *Dis Colon Rectum* 2006;**49**:825–32.
- van Zeeland, Genovesi IPO, Mulder JR, Strating PR, Glas AS, Engel AF. POSSUM predicts hospital mortality and long-term survival in patients with hip fractures. *J Trauma Acute Care Surg* 2011;**70**:E67.
- Moxey PW, Bronwnrigg J, Kumar SS, Crate G, Holt PJ, Thompson MM, et al. The BASIL survival prediction model in patients with peripheral arterial disease undergoing revascularisation in a university hospital setting and comparisons with the FINNVASC and modified PREVENT scores. *J Vasc Surg* 2013;**57**:1–8.
- Antoniou GA, Chalmers N, Georgiadis GS, Lazarides MK, Antoniou SA, Serracino-Inglott F, et al. A meta-analysis of endovascular versus surgical reconstruction of femoropopliteal arterial disease. *J Vasc Surg* 2013;**57**:242–53.
- Carpenter JP, Baum RA, Barker CF, Golden MA, Velazquez OC, Mitchell ME, et al. Durability of benefits of endovascular versus conventional abdominal aortic aneurysm repair. *J Vasc Surg* 2002;**35**:222–8.
- De Bruin JL, Baas AF, Buth J, Prinssen M, Verhoeven EL, Cuypers PW, et al. Long-term outcome of open or endovascular repair of abdominal aortic aneurysm. *N Engl J Med* 2010;**362**:1881–9.
- Rutherford RB. Vascular surgery – comparing outcomes. *J Vasc Surg* 1996;**23**:5–17.
- Midwinter MJ, Tytherleigh M, Ashley S. Estimation of mortality and morbidity risk in vascular surgery using POSSUM and the Portsmouth predictor equation. *Br J Surg* 1999;**86**:471–4.
- Back MR, Leo F, Cuthbertson D, Johnson BL, Shamesmd ML, Bandyk DF. Long-term survival after vascular surgery: specific influence of cardiac factors and implications for preoperative evaluation. *J Vasc Surg* 2004;**40**:752–60.
- Svensson LG, Crawford ES, Hess KR, Coselli JS, Safi HJ. Experience with 1509 patients undergoing thoracoabdominal aortic operations. *J Vasc Surg* 1993;**17**:357–70.
- Bradbury AW, Adam DJ, Bell J, Forbes JF, Fowkes FG, Gillespie I, et al. BASIL Trial Participants. Bypass versus Angioplasty in Severe Ischaemia of the Leg (BASIL) trial: an intention-to-treat analysis of amputation-free and overall survival in patients randomized to a bypass surgery-first or a balloon angioplasty-first revascularization strategy. *J Vasc Surg* 2010 May;**51**(Suppl. 5):5S–17S.
- Bradbury AW, Adam DJ, Bell J, Forbes JF, Fowkes FG, Gillespie I, et al. BASIL Trial Participants. Bypass versus Angioplasty in Severe Ischaemia of the Leg (BASIL) trial: a survival prediction model to facilitate clinical decision making. *J Vasc Surg* 2010 May;**51**(Suppl. 5):52S–68S.
- Forbes JF, Adam DJ, Bell J, Fowkes FG, Gillespie I, Raab GM, et al. BASIL trial Participants. Bypass versus Angioplasty in Severe Ischaemia of the Leg (BASIL) trial: health-related quality of life outcomes, resource utilization, and cost-effectiveness analysis. *J Vasc Surg* 2010 May;**51**(Suppl. 5):43S–51S.
- Conte MS. Critical appraisal of surgical revascularisation for critical limb ischaemia. *J Vasc Surg* 2013;**57**:8S–13S.