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Original Research

Convergence of Preoperative Measurements for Endovascular Aneurysm Repair and Their Association with Postoperative Renal Function

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Abstract

Aim: To assess concordance among preoperative measurements made by a radiologist, a vascular surgeon, and the device manufacturer's planning team for endovascular aneurysm repair (EVAR), and to explore the association between intraoperative contrast volume and postoperative change in renal function.

Material & Methods: In this prospective, consecutive, single-centre observational study, 40 patients undergoing EVAR were assessed. Three independent sets of preoperative measurements were compared using Bland-Altman analysis, paired t-tests, and absolute-agreement intraclass correlation coefficients. Paired changes in renal function and sac diameter were assessed using Wilcoxon signed-rank tests; exploratory associations between contrast volume and changes in renal function were assessed using Spearman correlation; and all-cause survival was estimated using Kaplan-Meier analysis.

Results: Radiologist measurements exceeded company measurements by a mean of 1.29 mm (95% limits of agreement -1.84 to 4.43 mm; ICC 0.80; n=34; p<0.001) and were 2.24 mm higher than surgeon measurements (n=21; p<0.001). The mean surgeon-company difference was -0.50 mm (n=20; p=0.404). Median paired eGFR values decreased by 5.0 mL/min/1.73 m² (n=26; p=0.017), while creatinine and urea increased by 5.5 µmol/L (n=30; p=0.002) and 1.2 mmol/L (n=17; p=0.003), respectively. Contrast volume was not significantly associated with changes in renal function (eGFR n=24, creatinine n=27, urea n=14; all p≥0.634). Across all recorded imaging, 17/40 patients (42.5%) had any endoleak, comprising 16 type II and one type Ib endoleak; no type III endoleaks were recorded. Paired sac-diameter measurements decreased significantly (n=20; p=0.018). Provisional overall survival was 94.4% at six months and 88.1% at both one and two years.

Conclusion: Measurements from the three planning sources were not fully interchangeable, supporting structured reconciliation of discrepancies during EVAR planning. Postoperative renal deterioration was observed, but the exploratory analysis did not identify a statistically significant association with contrast volume. Continued renal and imaging surveillance is warranted, and larger multicentre comparative studies are needed.

Keywords: *Endovascular Aneurysm Repair (EVAR); Renal Function; Contrast; Measurement; Endoleak; Triangulation; Gore*

Introduction

Accurate anatomical assessment and reproducible device sizing are central to endovascular aneurysm repair (EVAR) planning. The European Society for Vascular Surgery (ESVS) 2024 guidelines recommend detailed computed tomography angiography (CTA) assessment using dedicated post-processing software, consistent orthogonal measurements, and device selection appropriate to aorto-iliac anatomy and the manufacturer's instructions for use (IFU) in elective repair(1). Although these recommendations establish a framework for standardised planning, they do not specifically mandate three-way measurement triangulation between radiologists, vascular surgeons and device-manufacturer planning teams (1). Evaluating agreement across these sources therefore addresses a clinically relevant question: whether different participants in EVAR planning produce sufficiently consistent measurements to support shared sizing decisions(2, 3). Such triangulation provides an opportunity to identify systematic differences and the magnitude of individual discrepancies, rather than if multidisciplinary participation alone ensures measurement concordance(4).

Renal preservation is an equally important component of EVAR assessment. The ESVS guidelines recommend preoperative evaluation of creatinine and estimated glomerular filtration rate, adequate hydration in patients with renal impairment, and, specifically for complex endovascular aneurysm repair, consideration of strategies incorporating reduced iodinated contrast exposure(1, 5). The European Society of Urogenital Radiology similarly recommends the lowest contrast dose compatible with a diagnostic result and identifies large intra-arterial doses with first-pass renal exposure as a risk factor for contrast-associated acute kidney injury(6). These recommendations support minimising avoidable contrast exposure without compromising imaging adequacy, with dose interpreted alongside baseline renal function rather than against an arbitrary universal volume threshold(6). Against this background, the present prospective study evaluates cross-specialty measurement concordance and examines contrast volume alongside postoperative renal-function changes, addressing the complementary priorities of consistent procedural planning and renal safety without presuming that postoperative deterioration is attributable solely to contrast.

Material & Methods

Study Design: A prospective, consecutive, single-centre observational study was conducted over an approximately four-year period. The study included patients undergoing endovascular aneurysm repair (EVAR). Collected data included age, demographic characteristics, comorbidities, aneurysm dimensions, device details, intraoperative iodinated contrast volume, estimated blood loss, length of hospital stay (LOS), and perioperative renal function, including creatinine, estimated glomerular filtration rate (eGFR) and serum urea.

Preoperative planning measurements from a radiologist, a vascular surgeon and the device manufacturer's planning team were sought for each aneurysm; agreement analyses used available matched pairs. All procedures were performed using percutaneous access. Clinical endpoints included perioperative complications, groin access-site complications, endoleak and all-cause mortality. Endoleaks were classified according to standard types I–IV definitions (7). Patients underwent surveillance with ultrasound and CTA at predefined intervals. No patients were lost to vital-status follow-up, although imaging follow-up was incomplete for some patients.

Statistical Analysis: Continuous variables were summarised as medians with interquartile ranges (IQR), defined as the 25th–75th percentiles, and categorical variables as counts and percentages. Measurement agreement was assessed using Bland–Altman analysis. For each comparison, the difference was calculated as the first named measurement minus the second and plotted against the mean of the two measurements. Mean bias, its t-based 95% confidence interval (CI), and the 95% limits of agreement, calculated as mean bias ±1.96 standard deviations of the paired differences, were reported. Paired t-tests assessed whether mean bias differed from zero; a non-significant result was not interpreted as evidence of agreement. The two-way random-effects, absolute-agreement, single-measure intraclass correlation coefficient provided a complementary measure of agreement. Pair-specific sample sizes were reported.

Wilcoxon signed-rank tests compared paired preoperative and postoperative eGFR, creatinine and urea values, as well as paired baseline and follow-up sac diameters. One implausible follow-up sac-diameter value was treated as non-comparable and excluded from the paired sac analysis. These analyses assessed within-patient change rather than differences between unpaired group medians. For the descriptive sac-behaviour classification, unavailable or non-comparable follow-up values were categorised as unchanged.

Exploratory associations between intraoperative contrast volume and within-patient renal change were assessed using Spearman rank correlation, with reporting of the correlation coefficient, two-sided p-value and available paired sample size. These analyses were unadjusted and were not interpreted as evidence of contrast-induced renal injury.

All-cause survival was estimated using the Kaplan–Meier method, with time from surgery expressed in years. Survival estimates were accompanied by log–log 95% confidence intervals. Morbidity was summarised descriptively; morbidity-free Kaplan–Meier analysis was not undertaken because event and censoring dates were insufficiently established. All tests were two-sided, with $p<0.05$ considered statistically significant. Analyses were exploratory, with no adjustment for multiple comparisons, and were performed using Stat Plus version 7.8.11

Results

The cohort was a median age of 79 years (IQR 72.75–83), with a male predominance of 34/40 patients (85.0%). Hypertension was present in 27/39 patients (69.2%), ischaemic heart disease in 14/40 (35.0%), and diabetes mellitus in 11/40 (27.5%). The median preoperative aneurysm sac diameter was 6.2 cm (IQR 5.7–6.7). Median intraoperative contrast volume was 89 mL (IQR 72.5–102.5), estimated blood loss was 100 mL (IQR 50–200), and postoperative length of stay was 3 days (IQR 3–4) (Table 1).

Triangulation Outcome: The mean radiologist–company (n=34) and radiologist–surgeon (n=21) measurement differences were 1.29 mm and 2.24 mm, respectively; both were statistically significant ($p<0.001$). In contrast, the surgeon–company mean difference was −0.50 mm (n=20) and was not statistically significant (p=0.404). Agreement indices are presented in Table 2.

Renal Function & Contrast: Paired analysis demonstrated a median decline in eGFR of −5 mL/min/1.73 m² (n=26; p=0.017), with increases in creatinine of 5.5 µmol/L (n=30; p=0.002) and urea of 1.2 mmol/L (n=17; p=0.003). There was no statistically significant association between contrast volume and change in eGFR ($\rho=-0.040$; n=24; p=0.854), creatinine ($\rho=-0.045$; n=27; p=0.823), or urea ($\rho=0.140$; n=14; p=0.634) (Tables 3 and 4).

Table 1. Baseline and perioperative characteristics.

Variable	Median (IQR) or n/N (%)
Age in years	79 (IQR: 72.75–83)
Preoperative AAA/sac diameter, cm	6.2 cm (IQR: 5.7–6.7)
Intraoperative contrast, mL	89 ml (IQR: 72.5–102.5)
Estimated blood loss, mL	100 ml (IQR: 50–200)
Length of stay in days	3 (IQR: 3–4)
Male Gender	34/40 (85.0%)
Diabetes mellitus	11/40 (27.5%)
Hypertension	27/39 (69.2%)
Ischaemic heart disease	14/40 (35.0%)
Congestive heart failure	8/40 (20.0%)
Recorded CKD stage ≥3	12/39 (30.8%)

Table 2. Bland–Altman comparisons and agreement indices.

Difference	Mean bias (95% CI) in mm	95% limits in mm	P Value	ICC
Radiologist–company n=34	1.29 (0.74 to 1.85)	−1.84 to 4.43	<0.001	0.80
Radiologist–surgeon n=21	2.24 (1.36 to 3.12)	−1.55 to 6.03	<0.001	0.69
Surgeon–company n=20	−0.50 (−1.73 to 0.73)	−5.64 to 4.64	0.404	0.70

Table 3. Paired renal function before & after EVAR.

Measure	Preoperative	Postoperative	Within-patient change	p
eGFR n=26	66.5 (56.75–78)	65.5 (44.5–68.5)	−5 (−12.75 to −0.25)	0.017
Creatinine n=30	90.5 (79–102.5)	92 (88.25–119)	5.5 (0.25–17.5)	0.002
Urea n=17	6.9 (6.2–8)	8.2 (7.3–12.5)	1.2 (0.3–2.4)	0.003

n denotes patients with paired values. Values are median (IQR). Change = postoperative − preoperative. Wilcoxon signed-rank tests. Units: eGFR mL/min/1.73 m²; creatinine μmol/L; urea mmol/L. The median paired change is not the difference between the two group medians.

Table 4. Contrast volume versus within-patient renal change

Renal change	Spearman Test	P Value
eGFR n=24	-0.040	0.854
Creatinine n=27	-0.045	0.823
Urea n=14	0.140	0.634

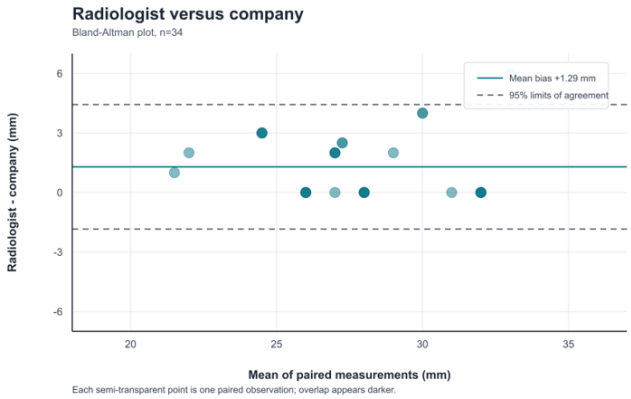


Figure 1. Bland–Altman plot of radiologist and company diameter measurements (n=34).

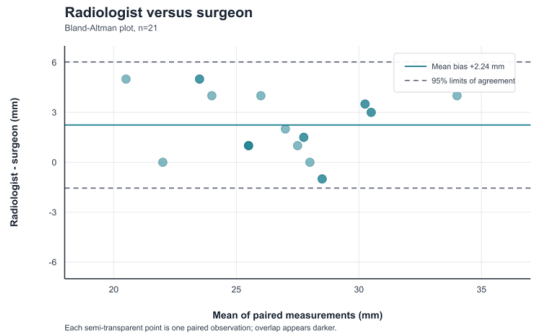


Figure 2. Bland–Altman plot of radiologist and surgeon diameter measurements (n=21).



Figure 3. Bland–Altman plot of surgeon and company diameter measurements (n=20).

Aneurysm Sac & Endoleak: There were no recorded 30-day deaths, major morbidity events or groin access-site complications. Across all recorded imaging, 17 of 40 patients (42.5%) had any endoleak: 16 (40.0%) had a type II endoleak and one (2.5%) had a type Ib endoleak; no type III endoleaks were recorded. Paired sac diameter decreased significantly in 20 patients with comparable baseline and follow-up measurements (p=0.018). When unavailable or non-comparable follow-up sac measurements were classified as unchanged, sac stability or regression was observed in 37 of 40 patients (92.5%), comprising 10 patients with regression of at least 5 mm and 27 with stable sac diameter. Of the 16 patients with type II endoleak, 13 demonstrated sac stability or regression. Three patients demonstrated sac expansion, ranging from 5 to 7 mm, of whom two had a recorded type II endoleak.

Median available follow-up was 0.24 years (IQR 0.14–0.95; n=38), with a maximum duration of 2.02 years. Two deaths occurred during follow-up, one attributable to cancer and the other to myocardial infarction. Provisional Kaplan–Meier overall survival was 94.4% (95% CI 66.6–99.2%) at six months and 88.1% (95% CI 60.2–96.9%) at both one and two years.

Discussion

The principal finding was that the three sources of preoperative EVAR measurements were not fully interchangeable. Bland–Altman analysis demonstrated systematic positive bias in comparisons involving the interventional radiologist. Radiologist-derived measurements were, on average, 1.29 mm greater than company-derived measurements (n=34; 95% CI 0.74–1.85 mm; 95% limits of agreement −1.84 to 4.43 mm; p<0.001) and 2.24 mm greater than surgeon-derived measurements (n=21; 95% CI 1.36–3.12 mm; 95% limits of agreement −1.55 to 6.03 mm; p<0.001). In contrast, there was no statistically significant systematic bias between surgeon- and company-derived measurements (n=20; −0.50 mm; 95% CI −1.73 to 0.73 mm; p=0.404). The ICC values, ranging from 0.69 to 0.80, indicate moderate-to-good overall agreement.

These findings support formal reconciliation of discrepant measurements during EVAR planning, particularly where a difference could affect device selection, sealing zone or procedural strategy, rather than assuming that measurements from different sources are equivalent. The single recorded type Ib endoleak and absence of type III endoleaks cannot be attributed causally to the planning approach(7). Early postoperative outcomes showed no 30-day mortality, morbidity or access-site complications. Across all recorded imaging, 17 of 40 patients (42.5%) had any endoleak: 16 (40.0%) had type II endoleak and one (2.5%) had type Ib endoleak; no type III endoleaks were recorded. Type II endoleaks, which are commonly associated with retrograde filling of the excluded aneurysm sac through patent collateral vessels, most often the lumbar arteries or inferior mesenteric artery.

Sac behaviour provides a more meaningful longer-term anatomical outcome in relation to appropriate sizing. Non-expansion of the aneurysm sac, defined as stability or regression, was noted in 37 of 40 patients (92.5%), comprising 10 patients (25.0%) with regression of at least 5 mm and 27 patients (67.5%) with stable sac diameter. Of the 16 patients with type II endoleaks, 13 (81.3%) demonstrated sac stability or regression. Three patients demonstrated sac expansion, ranging from 5 to 7 mm, of whom two had a recorded type II endoleak (7, 8).

The renal findings add an important clinical dimension to the anatomical and procedural outcomes. Paired analysis demonstrated a statistically significant median decline in eGFR of −5 mL/min/1.73 m² (IQR −12.75 to −0.25; n=26; p=0.017), accompanied by increases in creatinine of 5.5 µmol/L (IQR 0.25–17.5; n=30; p=0.002) and urea of 1.2 mmol/L (IQR 0.3–2.4; n=17; p=0.003). The concordant direction of change across all three indices suggests that postoperative renal function warrants attention even in the absence of major renal complications. However, no statistically significant association was identified between contrast volume and changes in eGFR (ρ=−0.040; n=24; p=0.854), creatinine (ρ=−0.045; n=27; p=0.823), or urea (ρ=0.140; n=14; p=0.634). This may partly reflect the relatively low median contrast volume of 89 mL (IQR 72.5–102.5 mL), which is substantially lower than the average volume reported in routine practice (10). It is important to note that renal impairment following EVAR is multifactorial, and the present findings support routine biochemical surveillance rather than reliance solely on major renal events (9, 10)

The median postoperative hospital stay was 3 days (IQR 3–4), consistent with recommended guidance (1). Median available follow-up was 0.24 years (IQR 0.14–0.95; n=38), with a maximum duration of 2.02 years. Two deaths occurred during follow-up, one attributed to cancer and the other to myocardial infarction. Provisional Kaplan–Meier overall survival was 94.4% at six months and 88.1% at both one and two years; however, the wide confidence intervals and relatively short median follow-up mean that these estimates should be interpreted cautiously. Overall, three-source measurement reconciliation was feasible and identified clinically relevant sizing discrepancies; its effect on clinical outcomes requires confirmation in larger comparative studies.

Limitations: Despite prospective data collection, the single-centre design, modest sample size, absence of a comparator group, incomplete sac-imaging follow-up and limited surveillance duration restrict external validity and preclude causal inference. The use of three independent planning assessments is a strength; however, it cannot establish that measurement reconciliation caused the observed type I and III endoleak rates, sac stability or regression, or the observed renal outcomes. Similarly, the absence of a significant association between contrast volume and postoperative renal change should be interpreted cautiously.

Conclusion

Three source preoperative measurement reconciliation was feasible and identified important differences in EVAR sizing assessments. The findings support a structured, multidisciplinary approach to preoperative planning, alongside continued postoperative renal and imaging surveillance. Larger multicentre comparative studies are required to determine whether this approach improves procedural and long-term clinical outcomes.

Conflict of Interest

The authors declare no conflict of interest.

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