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RESEARCH LETTER

## Pre-operative Low Muscle Mass Is Associated with Mortality Rate after Elective Abdominal Aortic Aneurysm Repair

Open surgical repair (OSR) of an abdominal aortic aneurysm (AAA) is a high risk procedure with a 30 day mortality rate of 3.0%—4.7%.[1,2] Endovascular aneurysm repair (EVAR) has an improved early post-operative outcome and has become the preferred treatment in high risk patients. Drawbacks of EVAR are the need for intensive follow up and frequent re-interventions.[1] The decision whether high risk AAA patients benefit more from EVAR or OSR is complex and demands accurate pre-operative risk assessment. Measurement of skeletal muscle mass on pre-operative computed tomography (CT) as a proxy for sarcopenia (defined by low muscle mass, strength, and performance) may improve risk stratification.[3] This single centre retrospective cohort study investigated the association between low muscle mass and survival after elective AAA surgery. The study protocol was approved by the local review board of the ethics committee (Medical research Ethics Committee United, number R&D/Z19.005).

Adult patients with asymptomatic AAA scheduled for elective EVAR or OSR between January 2012 and August 2018 at St Antonius hospital, The Netherlands, were included if abdominal CT images within six months prior to surgery were available. Exclusion criteria were prior abdominal aortic surgery, mycotic aneurysm, and poor quality or incomplete CT images.

Skeletal muscle mass was measured on CT using FatSeg software (Biomedical Imaging Group Rotterdam, Erasmus Medical Centre, Rotterdam, The Netherlands, using MeVisLab, Mevis Medical Solutions, Bremen, Germany).[4] Total cross sectional muscle area (CSMA) analysis was performed at the level of the third lumbar vertebra.[3] The inner and outer contour of the CSMA was traced manually and the tissue within the threshold of −30 to +150 Hounsfield Units (HU) was selected. Average tracing time was 5 min per patient. CSMA results were adjusted for height (skeletal muscle index [SMI]; $cm^2/m^2$). To analyse SMI, patients were divided into tertiles, based on SMI, and classified as low (lowest tertile) or normal muscle mass (middle and highest tertile).[3] Separate sex specific cut off values were determined. The association between low muscle mass and mortality rate was analysed with Cox proportional hazard models and adjusted for the Vascular-POSSUM physiology score (comorbidities), age, and surgical approach, resulting in a hazard ratio (HR) and 95% confidence intervals. Proportional hazard assumption was tested by visual inspection of log minus log plots.

In total 489 patients were included: 177 OSR (36.2%) and 312 EVAR patients (63.8%). The mean age was 71.6 years ± 7.8, mean Vascular-POSSUM physiology score was 17.9 ± 3.7, 306 patients (62.6%) were 70 years or older and the majority was male (86.5%). Low muscle mass was defined as SMI $\leq$45.1 $cm^2/m^2$ for males and $\leq$37.8 $cm^2/m^2$ for females. Patients with low muscle mass were older (74.4 *vs.* 70.2 years, $p < .001$), had more comorbidities (Vascular-POSSUM physiology score of 18.7 *vs.* 17.5, $p = .001$), and were more often treated by EVAR (114/312 [36.5%] *vs.* 49/177 [27.7%], $p = .046$). Median follow up was 42.0 months (interquartile range [IQR] 24.0—59.9 months) and 110/489 patients (22.5%) died during follow up. Overall mortality was 31.9% in patients with low muscle mass compared with 17.8% in patients with normal muscle mass (log rank $p < .001$). In the OSR and EVAR groups separately, survival was worse for patients with low muscle mass (log rank $p = .013$ for OSR and $p = .016$ for EVAR patients). The five year survival rate for OSR patients with low muscle mass was 58.0% and 84.0% for patients with normal muscle mass compared with 59.0% and 74.0% for EVAR patients. The adjusted HR for patients with low muscle mass was 1.50 (95% CI 1.01—2.23) (Table 1). The Vascular-POSSUM physiology score was also associated with death. The overall mortality rate was 31.3% in the highest tertile of the Vascular-POSSUM physiology score, compared with 16.0% in the middle and lowest tertiles (log rank $p < .001$). Five year survival rates were 75.0% and 78.0% for OSR, and 58.0% and 80.0% for EVAR, respectively. These results confirmed that low muscle mass was associated with lower survival, irrespective of the procedure and comorbidities.[3]

This study addresses several important issues. First, after adjustment for age, comorbidity, and surgical approach, low muscle mass was a significant risk factor for overall mortality after AAA surgery. Second, the five year survival rate

**Table 1.** Cox hazard analysis for all cause death in 489 patients after 312 endovascular or 177 open surgical aortic aneurysm repairs

| Variables | Univariable | | Multivariable | |
|---|---|---|---|---|
| | Hazard ratio (95% CI) | *p* value | Adjusted hazard ratio (95% CI) | *p* value |
| Low muscle mass | 1.93 (1.33—2.80) | .001 | 1.50 (1.01—2.23) | .044 |
| Age | 1.05 (1.02—1.08) | <.001 | 1.02 (0.98—1.05) | .34 |
| Comorbidity* | 1.15 (1.11—1.20) | <.001 | 1.14 (1.09—1.19) | <.001 |
| Open surgical repair | 0.76 (0.51—1.15) | .19 | 0.91 (0.59—1.40) | .66 |

* Vascular POSSUM physiology score, hazard ratio per point increase.

of patients with low muscle mass was poor in OSR and EVAR patients. The expected long term survival benefit for OSR over EVAR, as described in previous literature, did not apply for patients with low muscle mass in this study cohort.[5] Third, CSMA measurements can easily be performed in AAA patients, without additional burden.

There were several limitations. This was a single centre, retrospective cohort study. EVAR patients were older, with multiple comorbidities, and deemed unfit for OSR. Similar to other studies, SMI tertiles were used to define cut off values, causing possible selection bias. And lastly, measurements for muscle strength or performance were not performed.

In conclusion, pre-operative low muscle mass is associated with poor long term survival after AAA surgery, irrespective of surgical approach. Using CT scan imaging is a reliable and efficient method to identify patients with low muscle mass prior to surgery. When dedicated software becomes available for automatic muscle mass measurement, this information can be used to aid surgeons in their decision for OSR, EVAR or conservative treatment in AAA patients.

## CONFLICT OF INTEREST

None.

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