This reduction in aortic blood pressure may have a significant clinical benefit in the treatment of AAA and this will be discussed.

5254 Mo, 12:15-12:30 (P8)

Pulsatile movement of the zenith aortic stent-graft

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Objective: To measure the pulsatile movement of a bifurcated stent-graft, as the basis for pre-clinical durability testing.

Method: We performed high resolution cine-fluoroscopy in 39 patients immediately following abdominal aortic aneurysm repair with a Zenith stent-graft and at 1, 12, 24, and 36 months of follow-up. We compared systolic and diastole images to assess the movement of landmarks on the stent-graft in the pararenal aorta, in the neck, in the aneurysm, and at both ends of each limb. Two types of movement were observed: movement of the entire stent body, or pulsatile translation (PT), and expansion/contraction of the stent body, or pulsatile diameter change (PDC).

Results: Immediately after implantation, the mid-portion of the trunk showed the greatest pulsatile diameter change (PDC) from systole to diastole, but this segment also had the greatest decline in PDC over the first month of follow-up ($p = 0.03$). One month after stent-graft insertion, the mean PDC of the mid-aneurysm stent was less than 0.6% of its diastolic diameter. The PDC of the paranrenal stent and the stent within the neck also declined rapidly during the first month, but from a lower initial levels. After one month, PDC remained below 1.5% of the diastolic diameter at all stent landmarks. Pulsatile translation (PT) did not change with duration of follow-up. If anything, there was a non-significant trend towards an increase. The distal ends of the limbs had consistently lower PT ($p < 0.005$) than the body of the graft. The difference between the relative positions of the ends of the graft limbs and the main body of the graft in systole and diastole produced pulsatile limb bending.

Conclusions: All portions of the stent-graft ceased expanding and contracting to any significant degree within the one month of implantation. The observed PDC in these areas (approximately 1.0%) is far less than the 5.0% cyclical strain typically used as the basis pre-clinical finite element analysis and accelerated durability testing.

14.1.3. Endovascular Aneurysm Repair

7654 Mo, 14:00-14:30 (P11)

Wall stress analysis can predict the success of endovascular aneurysm repair

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Objective(s): To assess peak wall stress changes after successful endovascular aneurysm repair (EVAR) and also failure, represented here as type I/II endoleakage.

Methods: A 25 mm Talent endovascular stent-graft was deployed in a life-like non-axisymmetric latex abdominal aortic aneurysm model, which was incorporated into a pulsatile flow unit. This was surrounded by thrombus analogue. Strain gauges were placed at the neck ($n = 2$ 3), inflection point ($n = 4$ 3) and maximum anteroposterior diameter ($n = 4$ 3) resulting in 24 functional output channels. The arterial pressure settings used were 130/90 and 140/100 mmHg, termed the low and high setting respectively. Strain readings were obtained at 10 Hz over 30 seconds using a data logger before and after endograft deployment and after simulation of type I and II endoleaks. Stress was derived from its relationship with Young's modulus ($E = 5.151872\,\mathrm{Nmm}^{-2}$). Peak wall stresses were statistically analysed using ANOVA in Minitab 13.

Results (low/high settings): Peak stress was highest anteriorly and posteriorly at the inflection point (394.69 (SD 218.1) 10^{-4}/715.39 $10^{-4}\,\mathrm{N/cm}^{-2}$ (SD 230.32), $p < 0.001$, and 373.61(SD 207.24) 10^{-4}/1053.32 (SD 347.01) $10^{-4}\,\mathrm{Ncm}^{-2}$, $p < 0.001$). Type I endoleakage increased sac wall stresses (27.48–268.96/25.01–289.30 $10^{-4}\,\mathrm{Ncm}^{-2}$, $p < 0.001$), though these were equivocal at the neck and inflection point. Type II endoleakage also increased peak stresses (3.93–305.32/3.39–112.58 $10^{-4}\,\mathrm{Ncm}^{-2}$, $p < 0.001$) though some reductions were noted at the inflection point. However, stresses produced by type I endoleakage were higher than that caused by a type II endoleak ($p < 0.001$).

Conclusions: The therapeutic effect of EVAR is mediated by reduction of peak wall stresses. Type I endoleakage causes an increases in peak wall stress that may add to rupture risk. Stress reductions following type II endoleakage question whether this type needs treatment at all. This needs further validation *in vivo*, which if successful, may allow non-invasive biomechanical post-EVAR AAA monitoring using CT-derived data.

7486 Mo, 14:30-14:45 (P11)

An in vitro assessment of *Ancure* and *Zenith* abdominal aortic aneurysm stent-graft devices under physiological conditions

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Abdominal aortic aneurysms (AAA) are a major cause of death in the western world. Endovascular aneurysm repair (EVAR) is a less invasive procedure then the surgical method. Unfortunately stent graft devices have had many reported failures such as migration and endoleaks. Migration is one of the common causes and clinically most serious of the failure modes in AAA stent graft devices. The primary reason for this investigation is the assessment of prosthetic fixation, which is a vital to the long-term success of AAA Stent graft devices.

Idealized and realistic AAA models were fabricated from silicone using an injection molding technique. A computer controlled piston pump was used to simulate a range of physiological loading conditions. Two commercial stent graft devices, the Ancure (Guidant) and Zenith (Cook) were tested in this in vitro setup. Static dislodgement loads was applied to both stent graft devices in conjunction to pulsatile flow and non-pulsatile flow conditions.

A dislodgement force of 14 N and 4.8 N was found for both the Ancure and Zenith stent grafts respectively under no flow conditions A reduction of around 60% and 70% for the dislodgement force was found for the resting and exercise flow conditions respectively.

Heart rate, pulse pressure and aortic properties all influence the device performance, and in particular the long-term attachment of AAA stent grafts. The Zenith stent graft system has a greater dislodgement load due to its higher radial force and supra renal fixation. The increase in pressure due to variations in the physiological type pulses causing migration at a decreased dislodgement load. Knowledge of physiological type flows and pulse pressure may prove vital in the improvement of performance of patient specific devices by aiding the selection of stent graft type.

7457 Mo, 14:45-15:00 (P11)

A computational model for endovascular graft sizing in abdominal aortic aneurysms

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The sizing of endovascular grafts (EVG) for abdominal aortic aneurysm repair is a non-trivial procedure that often includes errors that compromise the quality of fit of the device and cause post-operative complications such as endoleaks and migration. In endovascular aneurysm repair (EVAR) secure device fixation at the proximal neck is critical for the long term success of the procedure. However, this often requires fitting a cylindrically shaped device to a tortuous conically shaped vessel lumen. This shape mismatch is typically addressed by oversizing the EVG a solution, however, that leads to a highly non uniform post operative stress distribution on the proximal neck wall and an equally non uniform device fixation strength. This in turn can lead to poor device post operative performance and arterial wall damage due to localized excessive tissue strain. Aim of this work is to model the fit of the EVG pre-operatively to predict the post-operative wall stress distribution in order to optimize device sizing. The EVG is modeled as a perfectly elastic isotropic material, the aortic wall as a hyperelastic isotropic material with zero residual stress, and the intraluminal thrombus as an elastic isotropic material [1]. Based on the known fully extended geometry of the EVG and the CT imaged 3D reconstructed aneurysmal true lumen geometry the initial stress distribution of the EVG that just fits in the AAA lumen is computed. This result is then prescribed as the initial EVG stress condition in the structural stress analysis of the EVG AAA assembly. The distribution of stress and frictional fixation force were computed. An initial validation of the proposed EVG fit modeling approach was achieved by comparing the model predicted fit geometry with the in vivo CT imaged 2-month post-operative EVAR geometry. Good agreement between the model fit and the post-operative fit was found.

References

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