Introduction
Cerebral ischemia and infarction is largely caused by ischemic stroke. Ischemic stroke occurs due to an occlusion of a major cerebral vessel providing blood supply to the brain. This occlusion is caused by an embolus such as plaque or, in the majority of cases a blood clot (thrombus) originating from another part of the vascular system (Gralla et al., 2008). To date, an extensive amount of research has been carried out using animals inducing the occurrence of ischemic stroke. The objective of this study is to experimentally assess typical lodgement locations of a physical blood clot in a patient specific flexible silicone model of the circle of Willis (CoW). Comprehending the issues associated with blood clot dynamics within the CoW will lead to greater understanding of cerebral stroke.

Materials and Methods
A MRA scan of a 57 year old female patient with no pathological findings was imported as a Dicom file into the Mimics software (Materialise, Leuven, Belgium) to generate the 3D model. A flexible silicone model was manufactured using the lost wax process by dipping a rapid prototyped ABS model using a dip spin technique on a custom fabricated rig in house. The model had 4 inlets and 12 outlets as shown in Figure 1 A & B. The diameters in the model varied from 0.7 - 5.2 mm, with the smaller diameters located in the middle cerebral arteries (MCA’s) and communicating arteries. Four computer controlled pulsatile flow waveforms were simulated into each of the inlet arteries. A water / glycerol mixture was used to mimic the blood’s viscosity. Clotted crustaceans (lobsters) blood was injected into the left and right internal carotid arteries (ICA’s) of the model. Repetitive injection of the clot (N=5) was carried out on each ICA separately. Dyes were used to identify direction of flow, impact locations and shifting of the flows within the CoW model before and after the introduction of the blood clot into the system. Clip on ultrasonic flow meters and pressure transducers monitored the flow rates and pressures respectively at the inlet and outlet vessels.

Results
The results showed that the clot lodged in the left and right MCA corresponding to the injected side in all cases as shown in Figure 1 C & D. During testing it was evident that the clot geometry changed in shape, this affected the flow path direction within the model. After lodgement of the clot, the outlet pressures dropped inside ischemic conditions in all tests.

Discussion
To the authors knowledge this is the first study to model the blood clot dynamics in a patient specific CoW model under pulsatile flow conditions. This rig provides a greater understanding of the blood clot dynamics and its influences on the hemodynamics flow features within the CoW.

References