# Transit-Time Flowmetry as Completion Control in Carotid Surgery

Thomas Mätzsch*, MD, Assoc. Prof., Anders Lundell MD, Ph.D.
Department of Vascular and Renal Disease
Malmö University Hospital, University of Lund, Sweden

The use of volume flowmetry in peripheral bypass surgery have been described in previous Medi-Stim Clinical Cases[1, 2.] The CardioMed Flowmeter has been thoroughly validated[3, 4]. The Butterfly and CardioMed Flowmeters are easy to use and suitable for peroperative detection of volume flow after vascular reconstructions.

## THE TRANSIT-TIME PRINCIPLE

In transit-time flowmetry the principle of measurement is based on ultrasound. However, instead of the Doppler effect, the time-difference required for an ultrasonic beam to pass through a moving blood-stream upstream (t1) and downstream (t2) is measured. The true volume flow is expressed in ml/min and is proportional to the integrated time difference (t2 - t1). This makes the transit-time flowmeter independent of vessel diameter, angle of insonation or haematocrit.

## EARLY CLINICAL EXPERIENCE AS COMPLETION CONTROL IN CAROTID SURGERY

The need for completion control after carotid endarterectomy is apparent since early occlusion or embolisation from the endarterectomy site may result in a perioperative stroke. The risk of restenosis is increased if technical imperfections during the initial operation remain undetected. Several methods have been proposed to ascertain that no such technical flaws are left behind. As examples, angiography, angioscopy or perioperative duplex can be mentioned. Most of these methods require invasive procedures, expensive equipment or are highly dependent on the skill of the investigator. In order to investigate whether the described technique of transit-time flowmetry can act as completion control after surgery for carotid artery stenosis, we started a pilot study and the preliminary results from our first patients are reported.

## METHOD

The study is designed as a prospective registration in 100 consecutive patients undergoing carotid endarterectomy (EA) for stenosis in the carotid artery. The registration was done using a standardised protocol completed during surgery. An 8 mm probe is placed around the common carotid artery (CCA) and the volume flow measured. The external carotid artery (ECA) and the internal carotid artery (ICA) are shortly clamped in succession while the blood flow is measured in each vessel. Care is taken to clamp at a location where the vessel is soft and free from arteriosclerotic plaque. This procedure is repeated immediately after restoration of the flow after EA and after an observation period of 10 minutes. During the observation period, the flow is surveilled using the trend-analysis function with the probe in place around the CCA. The results of the flow registrations can also be saved on the flowmeters hard-disc for purposes of documentation and later analysis. Statistical analysis has not been performed on this small sample.

## RESULTS

The first 37 patients constituted of 10 female and 27 male with a median age of 72 years (58-88). The flow in the CCA increased from 261 to 307 ml/min (mean increase 46 ml/min) after EA and in the ICA from 121 to 221 (mean increase 100 ml/min). In the ECA it decreased from 175 to 162 (mean decrease 13 ml/min). A slight increase in excess of these figures was seen in the flow immediately after restoration of flow following EA (figure 1).

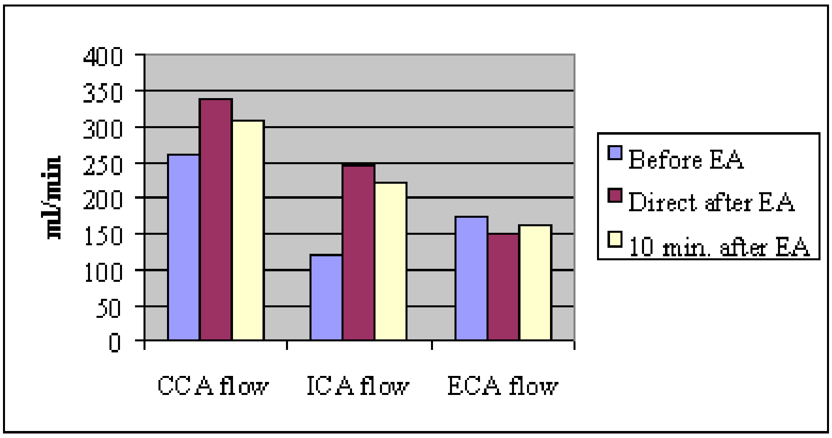



Figure 1. Carotid artery flow before, direct after and 10 minutes after carotid endarterectomy (EA).

In 6 of the operated 37 cases, the flowmetry had an impact on the surgical procedure: in three patients an unacceptable low, or during the observational period, decreasing flow in the external carotid artery made further interventions necessary. After correcting intimal flaps through separate incisions in the ECA, flow was normalised. In one case the flow in the ICA decreased during the observational period. An ongoing thrombusformation could be corrected and the arteriotomy closed with a patch. In another case, where the trend-analysis function was not used, the patient, who was operated in local anaesthesia, developed neurological symptoms during the observation period. Repeated flowmetry now revealed a decreased flow and reintervention was undertaken with full recovery of the neurological symptoms. In the last case, results of the flowmetry only led to extended diagnosis with use of Doppler-velocity measurement and renewed flow registration. In this case, an "orange" acoustical coupling indicator (ACI), i.e. poor detection of the ultrasound signal intensity had erroneously been accepted. No need for reintervention was found after correction of the probe position.

As an example of an operation that went uneventful, figure 2 shows the results of measurements before EA, figure 3 the flow registration using the trend-analysis function during the observation period of 10 minutes and figure 4 the flow at the end of the operation.

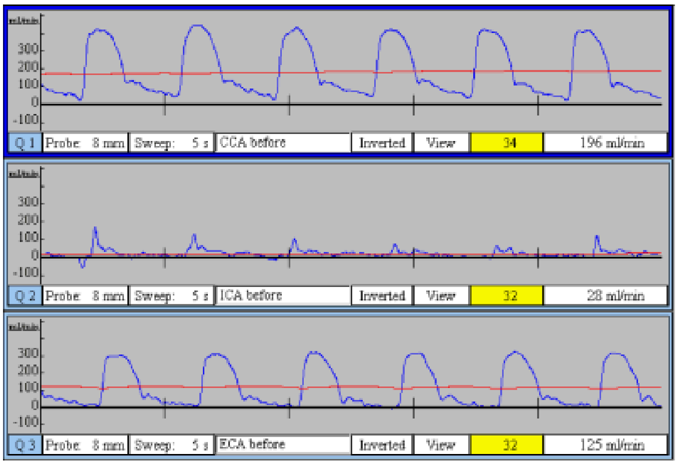



Figure 2. Pulsatile carotid artery flows (CCA, ICA and ECA) before EA.

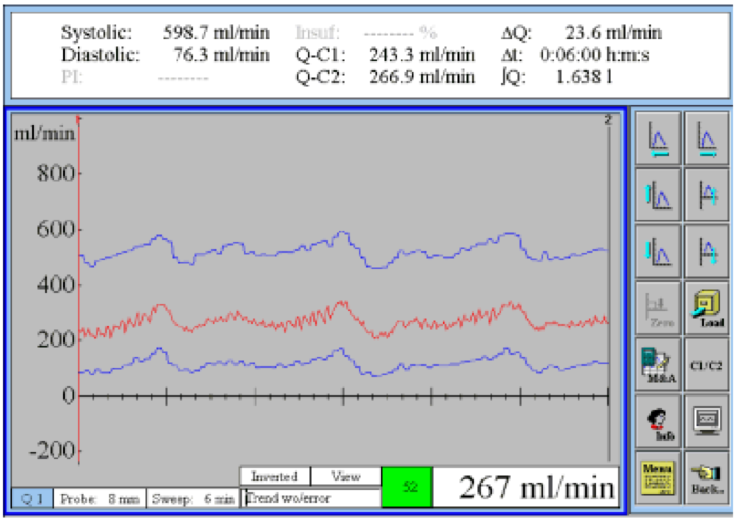



Figure 3. Trend recording of diastolic, mean and systolic ICA flow values during the 10 minutes observation period after EA.

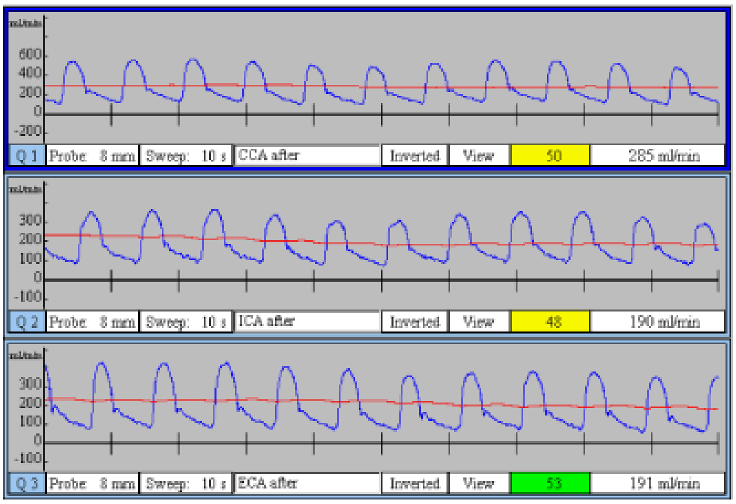



Figure 4. Pulsatile carotid artery flows after EA at the end of the procedure.

As an example where the transit-time flowmetry had a major impact on the surgical procedure, the figures 5-9 are shown. Figure 5 illustrates the flow before EA and figure 6 immediately after EA. During the observation period, decreased flow was noted in the trend analysis (fig. 7).

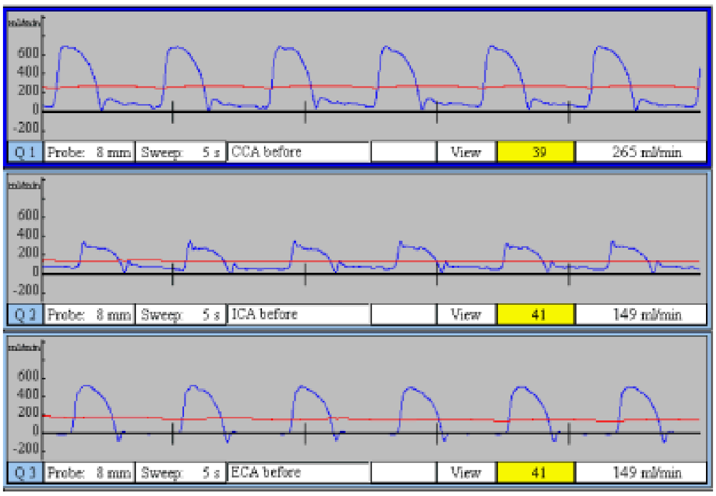



Figure 5. Pulsatile carotid artery flows before EA.

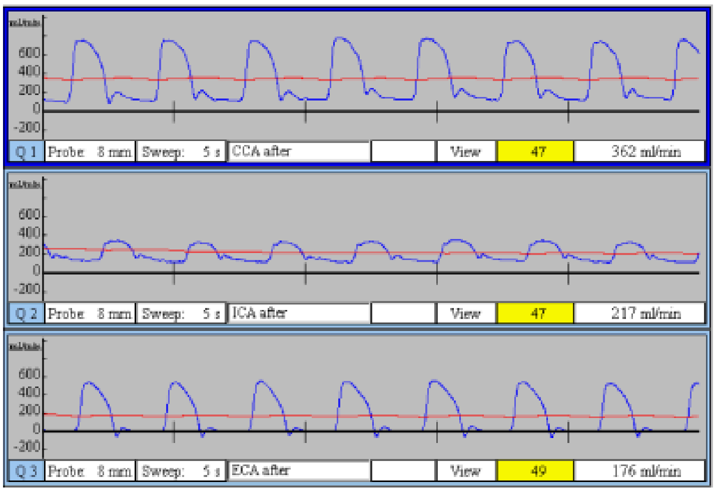



Figure 6. Pulsatile carotid artery flows immediately after EA.

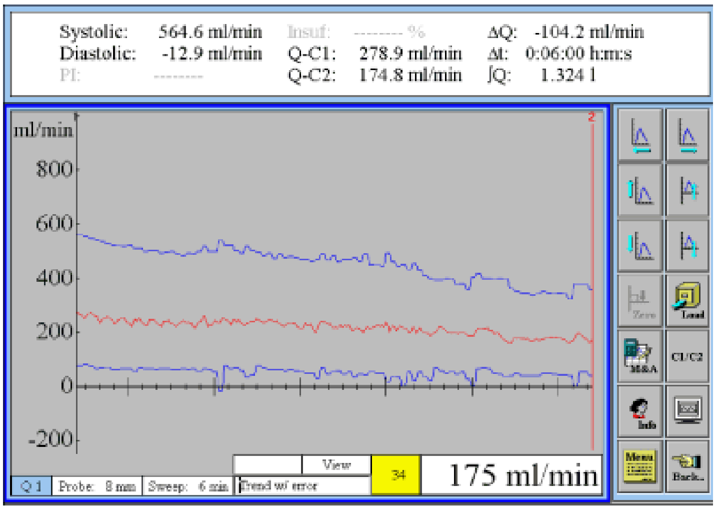
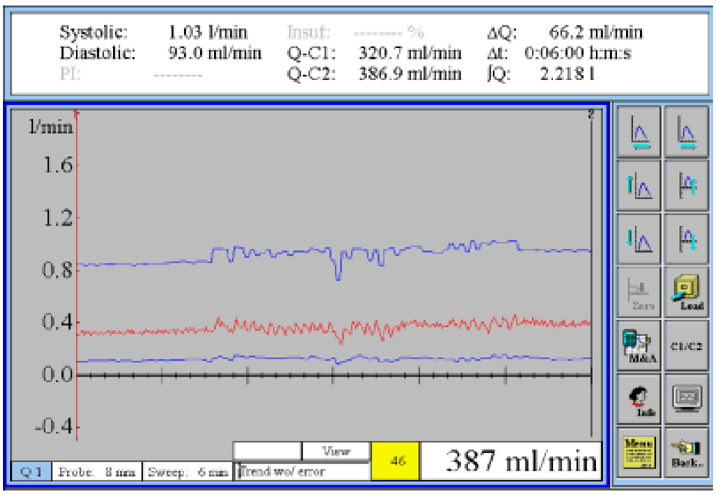



Figure 7. Trend recording of ICA flow after EA; decreasing flow values indicating thrombusformation at the site of EA.

The arteriotomy was reopened and a beginning thrombusformation at the endarterectomy site seen, but without any obvious cause. The site was cleansed and the arteriotomy closed with use of a patch. After completion, a stable, even slightly increasing flow was registered in the trend-analysis function during a second observational period (fig. 8). The flow measurements at the end of the operation differed only slightly from those received immediately after EA (fig.9).



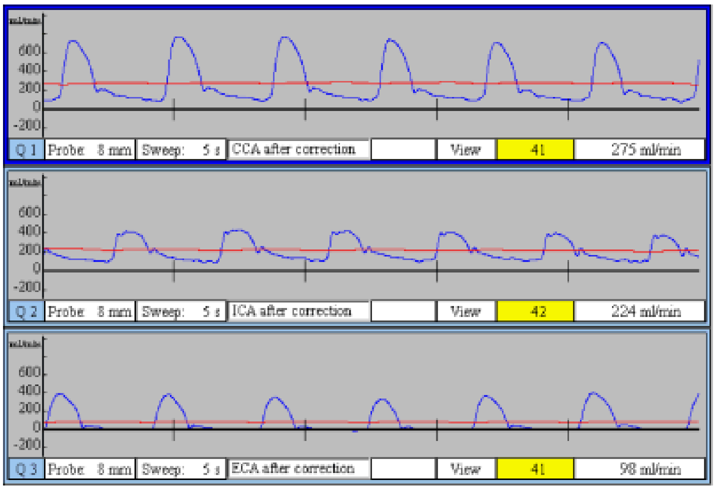



Figure 9. Pulsatile carotid artery flows after removal of thrombus and at end of the procedure.

The postoperative course was uneventful in this patient, but without the peroperative reintervention the risk for an occlusion of the ICA with a subsequent stroke must be considered very high.

## DISCUSSION

The method of transit-time flowmetry can reveal impairments of flow that necessitate immediate reintervention before occlusion or embolisation occurs. The absolute values of blood-flow vary considerably between individuals undergoing surgery for carotid stenosis, depending on severity of contralateral disease and established collaterals. Consequently, the relative alterations in flow seem to be more important than establishing a defined target volume flow. The lack of morphological information by the transit-time flowmetry is compensated for by the gained functional information about the actual blood-flow situation. The method is easy to use in a surgical setting during an operation and the presentation of data is stable and easily interpreted with only a short learning period.

We think it important to accept an observational period of 10 minutes between restoration of flow after EA and completion of the operation, as this will unmask any flow compromises. The trend-analysis function is helpful during this time. However, it must be stressed that only "green" or "yellow" ACI's (acoustical coupling indicator) are accepted during measurements, since poor signals will seriously affect the reliability of the results from the flowmetry.

The observation of an "over-shoot" in flow after restoration of flow is highly interesting and warrants further investigation. It may be explained with the effects of a reactive hyperaemia or alterations in flow distribution due to autoregulative processes.

Although it is still to early to accept transit-time flowmetry as a reliable method for completion control after carotid endarterectomy, the preliminary data seem promising and further studies are clearly motivated and needed.

References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*Please address all correspondence to: Dr. T. Mätzsch, Department of Vascular and Renal Diseases, Malmö University Hospital, SE-20502 Malmö, Sweden. E-mail: thomas.matzsch@kir.mas.lu.se

Correspondence related to the Flowmeter should be forwarded to: Medi-Stim ASA, Marketing Dept., PB 4744 Nydalen, N-0421 Oslo, Norway, or by using e-mail: medistim@medistim.com.