

Machine TMP is a misleading parameter to follow haemodialyser clotting

Floris Vanommeslaeghe¹, Wim Van Biesen¹, Stefaan Claus¹, Manual Dierick²,
Luc Van Hoorebeke², Annemie Dhondt¹, Sunny Eloot¹

Stefaan Claus

¹ Nephrology, Ghent University Hospital, Belgium

² Centre for X-ray Tomography, Physics and Astronomy, Ghent University, Belgium

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Background

In haemodialysis (HD) patients, **coagulation in the extracorporeal circuit** decreases dialysis efficiency and might result in patients blood loss in case of complete clotting.

Methods

Machine Trans Membrane Pressure (TMP) is one of the parameters routinely used to detect coagulation.

Results

This study uses a **golden standard CT scanning technique** to reflect haemodialyser clotting and to evaluate the accuracy of different machine parameters and visual scoring.

Conclusion

Background

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- **20 patients:**
 - 9F / 11M
 - Age 75 [69-79]
 - Body weight: 65 [58-72] kg
 - Double needle AVF / Double lumen CVC
 - Anticoagulation at dialysis start: all patients got their standard LMWH: Enoxaparin (Sanofi) or Tinzaparin (Leo Pharma)
- **Dialysis:**
 - 245±20min
 - FX600 Helixone dialyser
 - Fresenius 5008 dialysis machine
 - Post dilution HDF: 20±4 L substitution
 - $Q_B = 297 \pm 43$ mL/min
 - $Q_{UF} = 509 \pm 197$ mL/h

DURING DIALYSIS

Follow-up of different **dialysis parameters**

at different **time points**: 5, 60, 120, 150, 210 and 240min

- **Flow rates**: blood, dialysate, UF
- **Volumes**: blood, UF, substitution (HDF)
- **Pressures**: arterial, venous, TMP
- BVM, OCM

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	5min	60min	120min	150min	180min	210min	240min	270min	300min
Actuele tijd (...u...min)	7.25	8.20	9.20	9.50	10.41	11:50	11:25		
Q _B (mL/min)	300	300	350	350	350	350	350		
TMP (mmHg)	150	125	185	190	170	160	160		
Veneuze druk (mmHg)	105	115	130	125	130	130	125		
Arteriële druk (mmHg)	-140	-160	-195	-190	-195	195	-195		
Totaal bloedvolume (L)	1,9	16,8	34,2	44,1	55,0	65,1	76,7		
UF volume (mL)	55	479	947	1186	1431	1669	1800		
UF rate (mL/u)	475	475	475	475	475	475	475		
subvolume (L) (online)	0,5	4,2	8,2	10,4	12,7	14,8	14,8		
BVM (%)	98,6	91,3	90,4	90,2	88,2	88,8	87,1		
OCM (mL/min)		239	269	259	255	247	248		

AFTER DIALYSIS

Background

Dialysis parameter: Rinsing volume (machine)

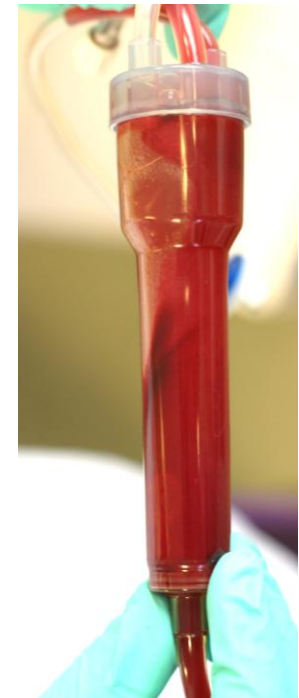
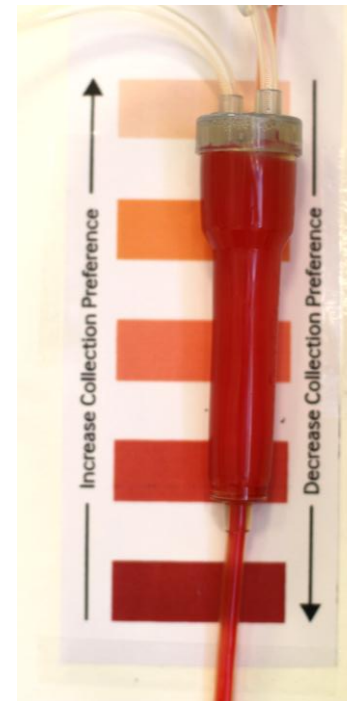
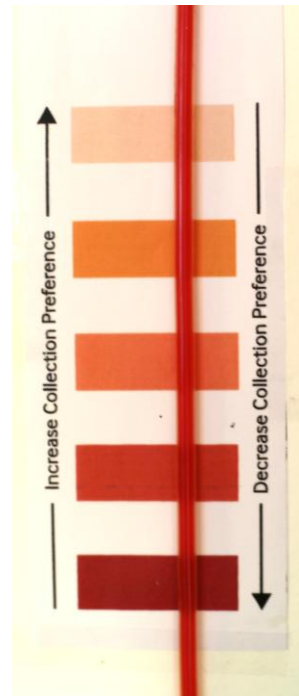
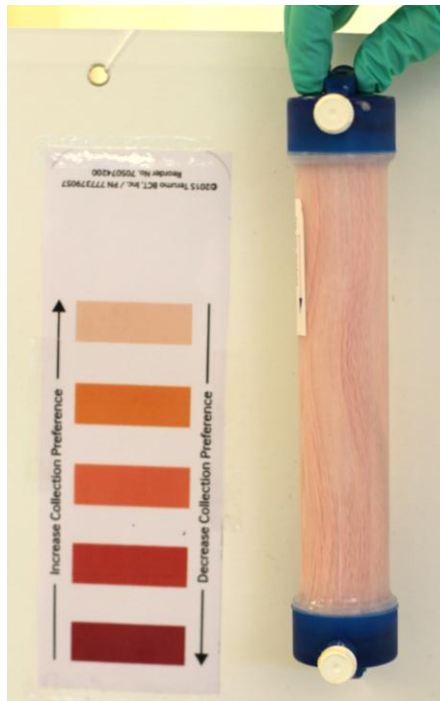
Visual scoring:

- Scoring: haemodialyser, venous line, venous chamber
- Length of clot

Methods

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AFTER DIALYSIS

Continuous positive pressure ventilation in the dialyser

- Simultaneously in blood & dialysate compartment
- 24h

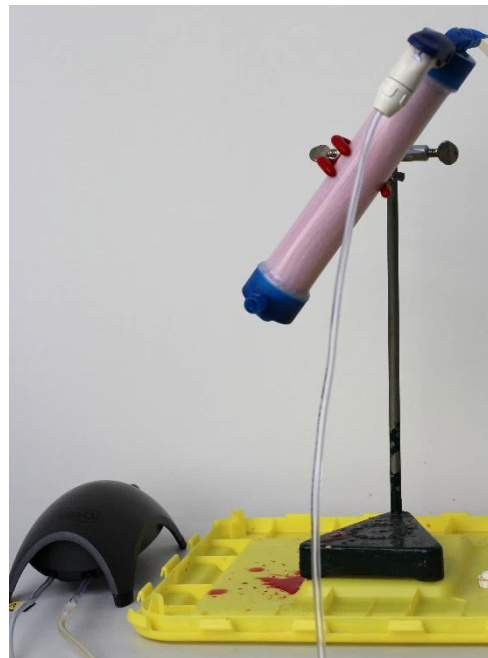
Dry mass of dialyser

Background

Methods

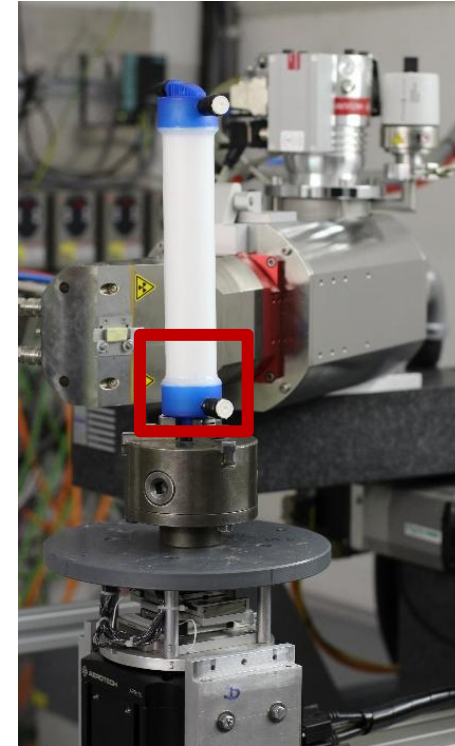
Results

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MICRO CT SCANNING

- 20 used dialysers / 3 sterile FX600
- Visualisation of potting at the blood outlet
- 4cm x 4cm (2000 pixels x 2000 pixels)
- Resolution 25 μ m (voxel size)
- 2401 projections x 0,5s



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FIBER COUNTING

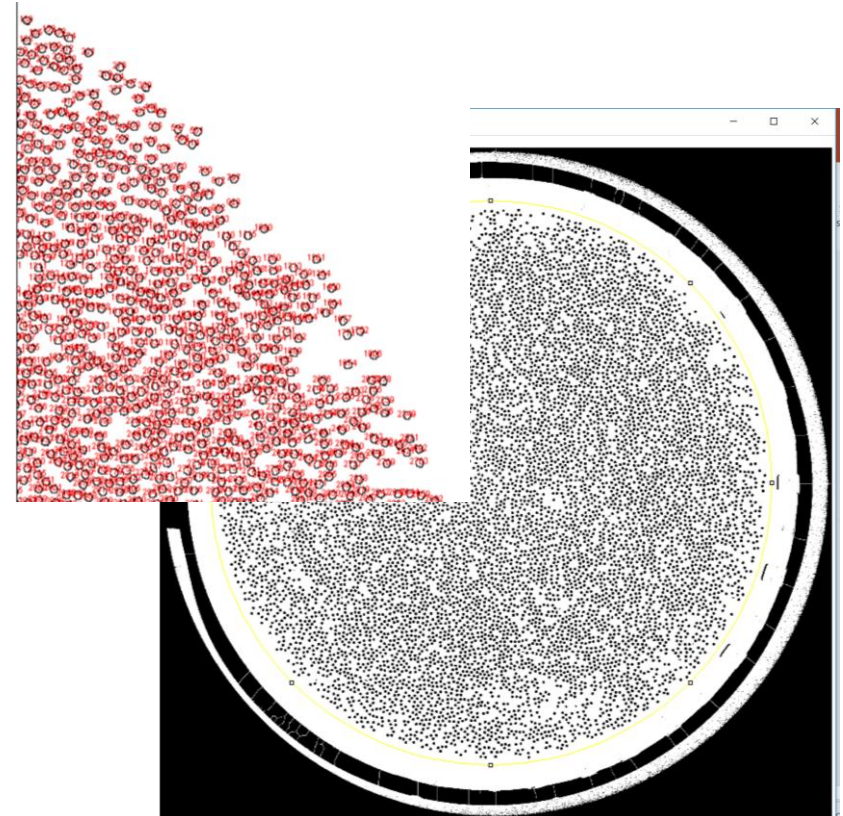
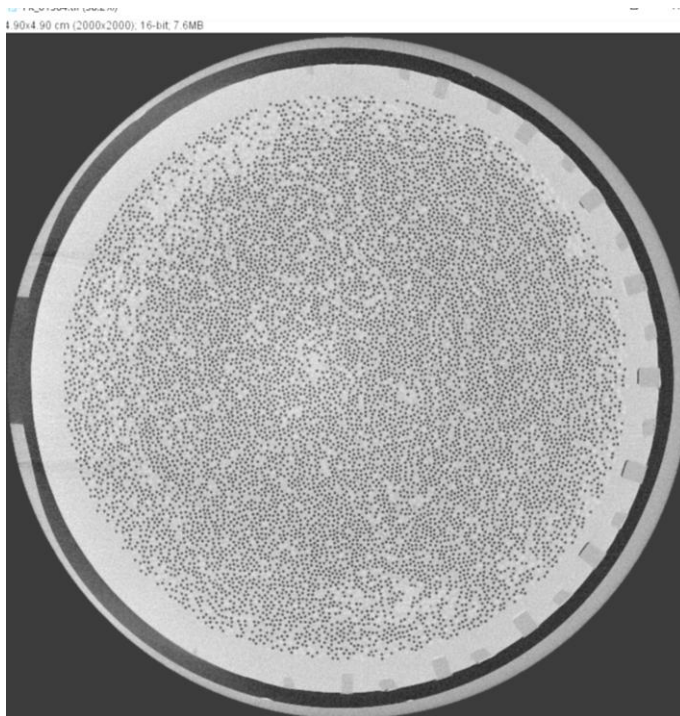
- Reconstruction of CT scans: 3D → slices (e.g. 460 in potting)
- Selection of slice halfway potting (ImageJ, Fiji)
- Selection of fibers with surface area > 60% theoretical fiber (>0,0002cm²)

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CORRELATIONS ?

Dialysis parameters



Number of open fibers

Arterial pressure

Venous pressure

TMP (transmembrane pressure)

BVM (blood volume monitoring)

OCM (online clearance monitoring)

UF (ultrafiltration volume)

Substitution volume

Rinsing volume

Visual scoring of dialyser

Visual scoring of venous line

Visual scoring of venous chamber

Dry mass of dialyser

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OPEN FIBERS:

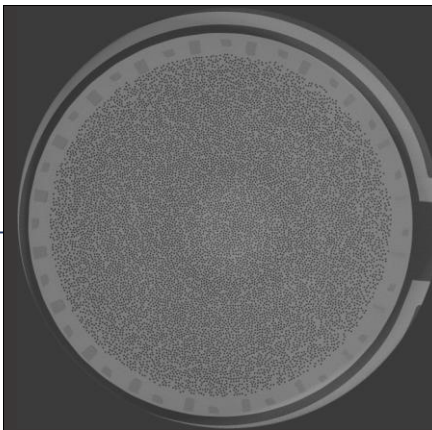
non-used dialysers:

10748 ± 2

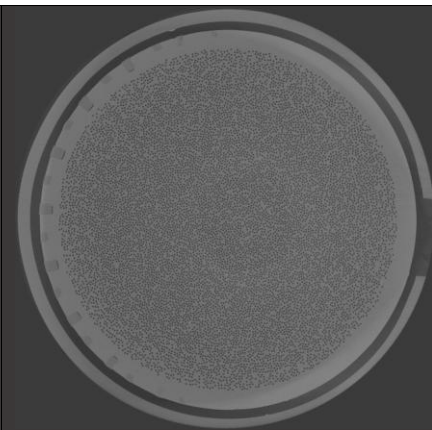
used FX600:

8930 ± 2465

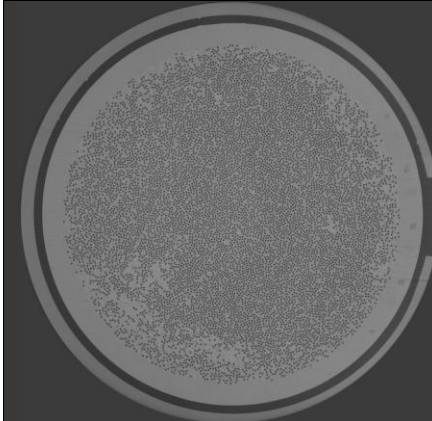
[range 534-10692].



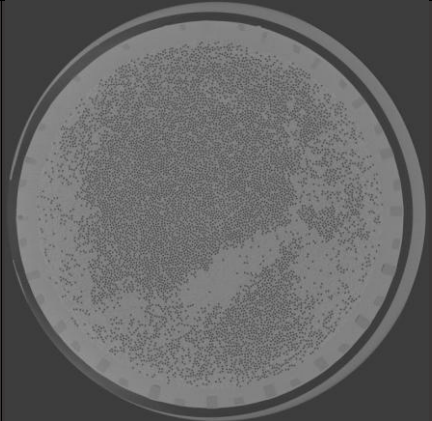
Non-used dialyzer



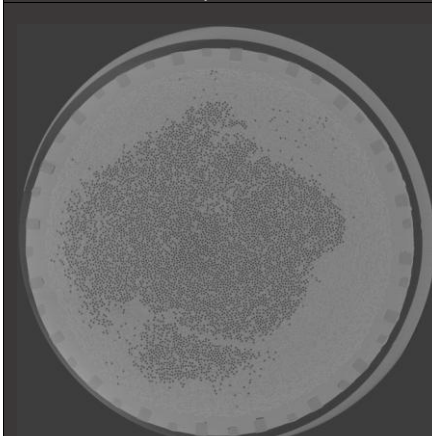
99.5 % patent fibers



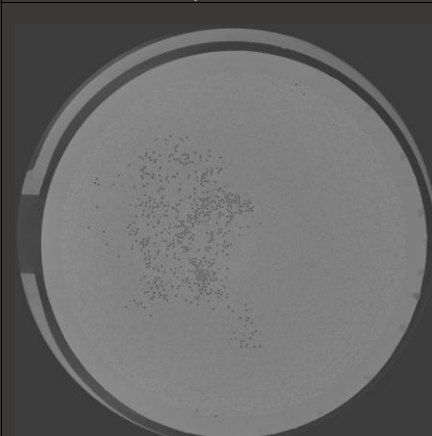
90.7 % patent fibers



71 % patent fibers



50.6 % patent fibers



5 % patent fibers

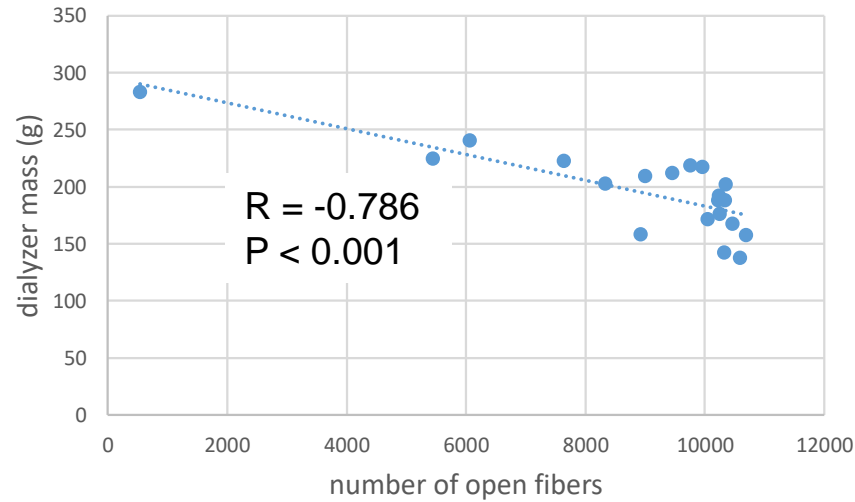
Background

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Dry mass dialyser



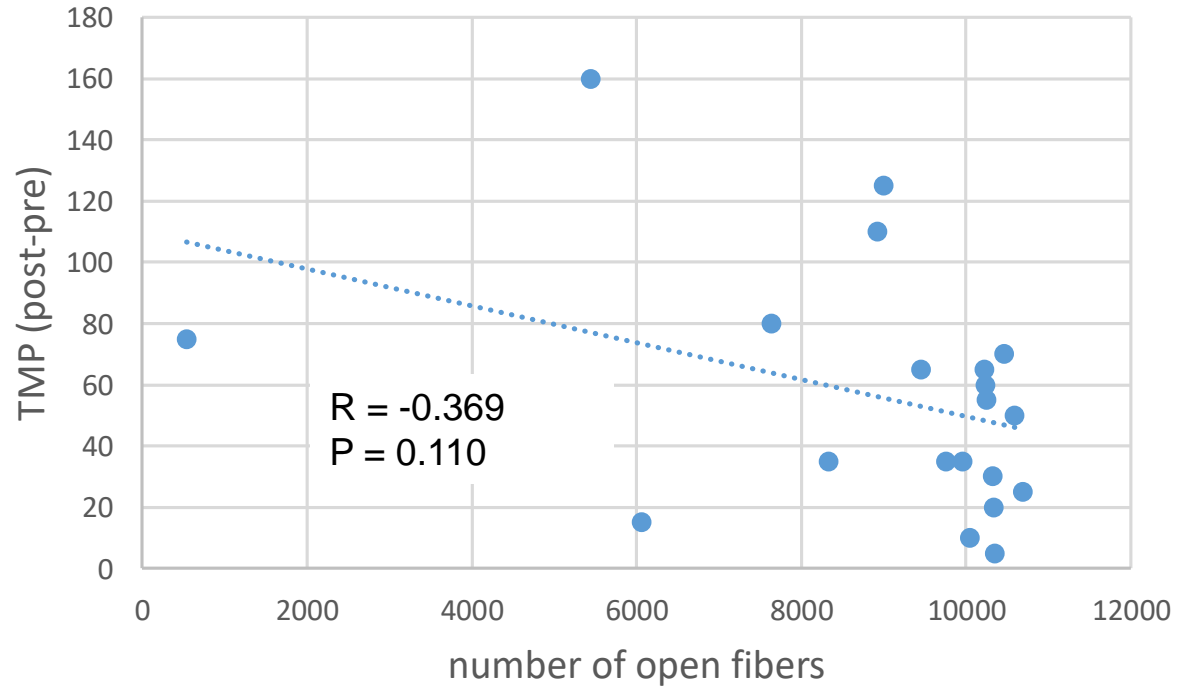
Background

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TMP (post versus pre HD)

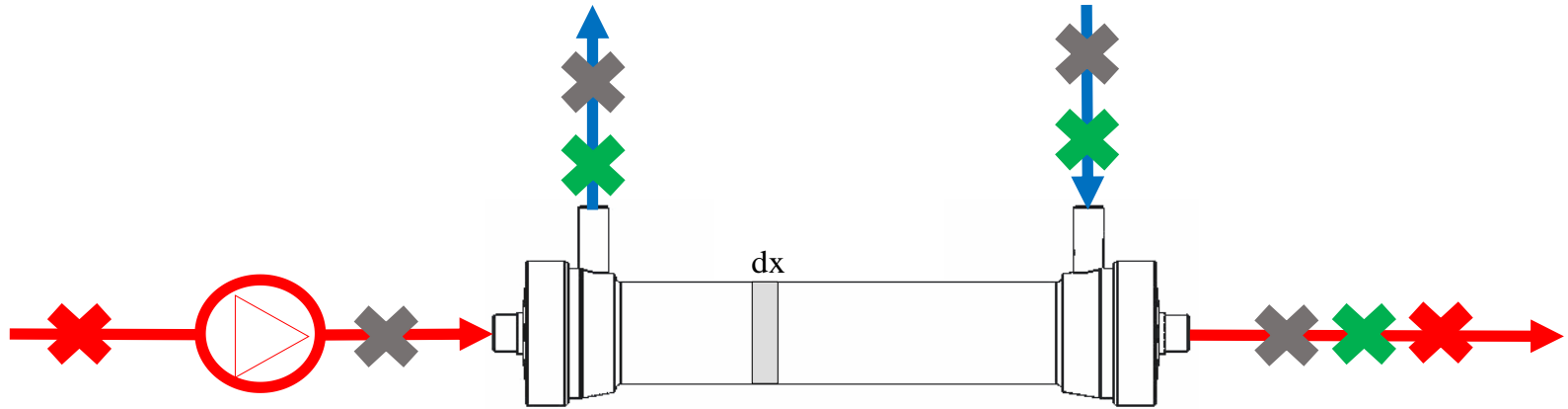


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X Arterial and Venous Pressures on dialysis machine

Fresenius 5008 - 3 - points meting : **X**

$$\text{TMP} = P_{\text{postfilter}} - \frac{P_{\text{dial inlet}} + P_{\text{dial outlet}}}{2} + \text{offset}$$

offset = 20 – 50

Theoretical TMP - 4 - points meting **X**

$$\text{TMP} = \frac{P_{\text{pre filter}} + P_{\text{postfilter}}}{2} - \frac{P_{\text{dial inlet}} + P_{\text{dial outlet}}}{2} - \pi$$

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Although popular, machine TMP cannot accurately predict coagulation in the extracorporeal circuit.

Micro-CT scanning represents a feasible, non-invasive, accurate and reproducible tool for quantification of blocking of fibers in a haemodialyser making it an **objective golden standard** for studies on anticoagulation in HD

