ANNEXES TO CHAPTER 5

Clinical question XXIII. In the high-flow arteriovenous fistula, what therapeutic approach should be taken and what are the criteria (risk factors)?

Criteria (risk factors) for deciding whether or not to intervene in a high-flow fistula	
Miller (2012) feels that the ideal flow rate for haemodialysis access should be sufficient to prevent thrombosis while maximising dialysis efficiency. The author considers flow rates in the range of 600 to 1,500 ml/min to be desirable or normal. Miller classifies high-flow fistulas as those with a flow rate of between 1,500 and 4,000 ml/min. Vaes (2013) considers a flow rate of 400–600 ml/min in arteriovenous fistulas as being generally sufficient for effective exchange during haemodialysis, and points out that even though there is no broadly-agreed definition on what constitutes high flow, a cut-off point of 2000 ml/min is usually used, given that some studies have found heart failure to be more common in haemodialysis patients with an access flow rate above this figure. The existence of a hyperfunctioning high-flow fistula has been associated with several potential problems: cardiac overload, cardiopulmonary recirculation, rapid growth of the access with the formation of aneurysms, recurring venous stenosis causing access failure and lack of correspondence between entry and exit flow rate (Miller 2012). It can also cause steal syndrome or venous hypertension in the absence of central venous stenosis. Intervention is required upon the diagnosis of any of these conditions to try and solve or mitigate the problem, while also attempting to preserve the vascular access. In some cases, high flow detection is often a chance finding from a routine measurement (Vaes 2013), which, if confirmed on repeated occasions, raises the question of whether or not a flow reduction procedure should be carried out. However, the decision to initiate treatment is controversial due to the lack of absolute criteria for starting treatment. Furthermore, no studies in the scientific literature have been found that compare the clinical course of high-flow fistula patients who have received flow-reduction treatment versus those who have not. The available evidence comes from expert opinions and clinical series, and is therefore of poor quality.	
Both Miller (2012) and Vaes (2013) feel that the therapeutic approach should depend on each patient's medical history and clinical condition. For example, it makes sense for a patient with a high-flow fistula and compromised cardiac function to undergo an access flow reduction procedure, given that he/she will end up developing an additional cardiac event sooner or later if this procedure is not performed. But it also appears to be a sensible decision to not intervene if a high-flow fistula is detected in a young patient with normal cardiac function, if he/she is awaiting a kidney transplant. Vaes (2013) also recommends intervening when the patient presents with symptoms of ischaemia of the hand, usually in the context of steal syndrome	**Low quality**

With regards to indications for intervention, Miller (2012) also includes the clinical presence of a mega-fistula, aneurysm at the access site, peripheral and central venous stenosis and cases in which the entry and exit flow rate is different, causing inflammation in the arm and access dysfunction. **Therapeutic options** There are two main techniques for reducing high flow in fistulas: the banding technique and the RUDI (revision using distal inflow) technique.	
BANDING: tightening of the artery to treat the high flow	
High flow in a fistula is caused by hypertrophy of the arterial system combined with low venous resistance to the flow. The transport capacity of the artery depends on its diameter, with an increase of 1 mm causing the flow capacity to double. Banding consists of placing a highly resistant band around the vein. It is a minimally invasive percutaneous procedure that is performed with a balloon catheter to obtain the desired diameter. Various clinical series demonstrate the efficacy of banding procedures.	**Low quality**
Miller (2010 a) published a study with 183 patients treated by banding. Complete remission of the symptoms was achieved in 109 of the 114 patients who had ischaemia of the hand due to steal syndrome, and in all 69 patients with high flow and conditions such as congestive heart failure. Primary patency at six months was 75% and 85%, respectively. Secondary patency at 24 months was 90%, with the thrombosis rates being 0.21, 0.10 and 0.92 per year with upper arm, forearm and graft fistula access, respectively.	**Low quality**
Two clinical series analysed the banding technique in patients with central venous stenosis. Jennings (2012) used banding in 22 patients with high flow due to central venous occlusion and extremity inflammation. The inflammation disappeared immediately in 20 of the patients and showed significant improvement in the other two. The average flow rate dropped from 1,640 ml/min to 820 ml/minute after the intervention ($P < 0.01$). Two of the fistulas failed; one at 8 months and the other at 13 months. Miller (2010 b) analysed the effect of banding in 33 patients with brachiocephalic artery stenosis, followed-up for an average of 14.5 months. Patency at 3, 6 and 12 months was 91%, 76% and 57%, respectively. The intervention rate on the brachiocephalic artery dropped from 3.34 to 0.9 per year of access.	**Low quality**
Schneider (2006) describes a different type of banding, known as T-banding. This method, which aims to prevent possible graft displacement, was used in 22 patients, 20 of whom had heart failure (six of whom also suffering from steal syndrome), and the two remaining patients only with steal syndrome. The study found a median flow rate reduction of 44% (range from 27% to 71%). The average preoperative flow rate was 1,956 ml/min, which dropped to 983 ml/min one month after the operation. The symptoms of 72% of the patients completely disappeared, with four patients improving somewhat but still requiring another procedure to completely rid themselves of the symptoms. The intervention was deemed successful in 95% (19/20) of the patients with heart failure, and in 83% of the patients suffering with steal syndrome (5/6). The access continued to be used in all patients, with a primary patency of 90% and a secondary patency of 100% at one to three months.	**Low quality**

RUDI	
The RUDI technique (radial artery ligation) is usually reserved for larger high flow-AVFs (arteriovenous fistulas), and is a surgical procedure by which the fistula is ligated beside the anastomosis before being re-connected to the most distal artery. The technique adds resistance to the circuit, because it connects it to a smaller artery and elongates the fistula with a bypass of a smaller diameter.	**Low quality**
PRAL	
The prospective study by Bourquelot (2010) included 37 patients (8 children and 29 adults) who underwent PRAL (proximal radial artery ligation) to treat high flow in radiocephalic fistulas: 2 due to ischaemia, 14 due to aneurysmal degeneration of the vein, 7 due to heart failure and 14 to prevent cardiac overload. The mean age of the fistula was 2.6 years in the children and 7.4 years in the adults. The success rate was 92% (34/37). The three failures included one excessive and two insufficient flow rate reductions (<33%). The average flow rate reduction was 50% in children and 53% in adults. The primary patency rates at 1 and 2 years were 88% and 74%, respectively. The secondary patency rates were 88% and 78%, respectively.	**Low quality**
Transposition of the radial artery	
Another study by Bourquelot (2009) analysed 47 patients (22 women) with brachial artery fistula to the elbow vein, who underwent flow rate reduction treatment by replacing the brachial artery by transposition of the distal radial artery. The indications for the treatment were ischaemia of the hand (4), heart failure (13), concerns about future cardiac dysfunction (23) and chronic venous hypertension causing aneurysmal degeneration of the vein (7). The average age of patients was 44 years, 11% were diabetic, 17% were smokers and the mean BMI was 22. The mean age of the fistula before the flow rate reduction was 2.5 years. The success rate of the technique was 91% (43 out of 47). The mean flow rate was reduced by 66%. The clinical success in symptomatic patients was 75% (18 out of 24). The fistula ultimately had to be ligated in three cases of heart failure due to insufficient clinical improvement. The four patients with ischaemia of the hand recovered, with no recurrence during follow-up. The primary patency rates at one and three years were 61% and 40%, respectively. The secondary patency rates at one and three years were 89% and 7%, respectively.	**Low quality**
Ultrasound-guided flow rate reduction surgery	
Tellioglu (2008) analysed the role of Doppler ultrasonography-guided surgery in 30 patients with high-flow accesses, 25 fistulas and 5 grafts. The indications for the operation were as follows: heart failure (n=18) or steal syndrome (n=12). The criteria for defining vascular access as "high flow" were >800 ml/min for fistulas and >1,200 ml/min for VA. The desired post-operative flow rate was 400 ml/min for the fistula and 800 ml/min for the graft. There were 16 male patients and 14 female patients, with a mean age of 48 years (range, 39–57 years). The median preoperative measurements of the AV fistula, flow rate of the AV graft and diameter of the anastomosis were as follows: 2,663 ml/min (range, 1856–3440 ml/min);	**Low quality**

2,751 ml/min (range 2,140 ml/min to 3,584 ml/min) and 7.3 mm (range, 6.1 mm to 8.5 mm), respectively. The flow rate was reduced to 615 ml/min (range, from 552 ml/min to 810 ml/min) for the fistulas and 805 ml/min (range, from 745 ml/min to 980 ml/min) for the grafts. The average diameter of the anastomosis was reduced to 4 mm (range, 3.5 mm to 4.3 mm). No interventions were repeated. After a median follow-up of 1 year, the patency rates were 100% for AV fistulas and 80% for the grafts. The cardiac output rate decreased from 8.5 l/min to 6.1 l/min ($p<0.01$).	
Summary of the evidence	
Some clinical series demonstrate that the banding technique and the RUDI technique are effective in reducing high flow rates in fistulas and achieving remission of the symptoms of steal syndrome and congestive heart failure related to high flow.	**Low quality**
Patient values and preferences *No relevant studies on this aspect have been found.*	
Use of resources and costs *No relevant studies on this aspect have been found.*	
Recommendations [Proposal]	
Weak	In patients with a high-flow fistula and related conditions (steal syndrome or heart failure), intervention is recommended with the banding technique or the RUDI technique.

References

Bourquelot P, Gaudric J, Turmel-Rodrigues L, Franco G, Van Laere O, Raynaud A. Transposition of radial artery for reduction of excessive high-flow in autogenous arm accesses for hemodialysis. J Vasc Surg. 2009 Feb; 49(2):424-8, 428.e1.

Bourquelot P, Gaudric J, Turmel-Rodrigues L, Franco G, Van Laere O, Raynaud A. Proximal radial artery ligation (PRAL) for reduction of flow in autogenous radial cephalic accesses for haemodialysis. Eur J Vasc Endovasc Surg. 2010 Jul; 40(1):94-9.

Chen CF, Hsu SW, Ko SF, Chen KY. High-flow hemodialysis arteriovenous shunt with concurrent central vein stenosis masquerading as sigmoid sinus dural arteriovenous fistula. Clin Neuroradiol. 2013 Mar; 23(1):59-62.

Durack JC, Wang JH, Schneider DB, Kerlan RK. Vena cava filter scaffold to prevent migration of embolic materials in the treatment of a massive renal arteriovenous malformation. J Vasc Interv Radiol. 2012 Mar; 23(3):413-6.

Jennings WC, Miller GA, Coburn MZ, Howard CA, Lawless MA. Vascular access flow reduction for arteriovenous fistula salvage in symptomatic patients with central venous occlusion. J Vasc Access. 2012 Apr-Jun; 13(2):157-62.

Miller GA, Hwang WW. Challenges and management of high-flow arteriovenous fistulae.Semin Nephrol. 2012 Nov; 32(6):545-50.

Miller GA, Goel N, Friedman A, Khariton A, Jotwani MC, Savransky Y, Khariton K, Arnold WP, Preddie DC. The MILLER banding procedure is an effective method for treating dialysis-associated steal syndrome. Kidney Int.

2010 Feb; 77(4):359-66.

Miller GA, Friedman A, Khariton A, Preddie DC, Savransky Y. Access flow reduction and recurrent symptomatic cephalic arch stenosis in brachiocephalic hemodialysis arteriovenous fistulas. J Vasc Access. 2010 Oct-Dec; 11(4):281-7.

Resnick S, Chiang A. Transcatheter embolization of a high-flow renal arteriovenous fistula with use of a constrained wallstent to prevent coil migration. J Vasc Interv Radiol. 2006 Feb; 17(2 Pt 1):363-7.

Osawa T, Watarai Y, Morita K, Kakizaki H, Nonomura K. Surgery for giant high-flow renal arteriovenous fistula: experience in one institution. BJU Int. 2006 Apr; 97(4):794-8.

Schneider CG, Gawad KA, Strate T, Pfalzer B, Izbicki JR. T-banding: a technique for flow reduction of a hyperfunctioning arteriovenous fistula. J Vasc Surg. 2006 Feb; 43(2):402-5.

Tellioglu G, Berber I, Kilicoglu G, Seymen P, Kara M, Titiz I. Doppler ultrasonography-guided surgery for high- flow hemodialysis vascular access: preliminary results. Transplant Proc. 2008 Jan-Feb; 40(1):87-9.

Vaes RH, Tordoir JH, Scheltinga MR. Systemic effects of a high-flow arteriovenous fistula for hemodialysis. J Vasc Access. 2013 Oct 29; 0(0):0. doi: 10.5301/jva.5000196. [Epub ahead of print]

Table 1. EXCLUDED STUDIES

Study	Reason for exclusion
Osawa (2006)	About renal fistula, not vascular access.
Resnick	About renal fistula, not vascular access.
Durack (2012)	About treatment of renal arteriovenous malformations.
Chen (2013)	Case of brain fistula.

GRADE TABLES

Date: 2013-12-17
Question: Should BANDING, tightening of the artery be used to treat the high flow?
Bibliography: Miller (2010), Jennings (2012), Schneider (2006)

Quality assessment							No. of patients		Effect		Quality	Importance
No. of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	BANDING: tightening of the artery	Control	Relative (95% CI)	Absolute		
Primary permeability												
3	observational studies[1]	very serious[1]	no serious inconsistency	no serious indirectness	no serious imprecision	none	-	-	-	-		CRITICAL
Improvement of clinical symptoms												
3	observational studies[1]	very serious[1]	no serious inconsistency	no serious indirectness	no serious imprecision	none	-	-	-	-		CRITICAL
Decreased flow (Better indicated by higher values)												
3	observational studies[1]	very serious[1]	no serious inconsistency	no serious indirectness	no serious imprecision	none	77	-	-	-		CRITICAL

[1] case series

Date: 2013-12-17
Question: Should echo-guided flow reduction arterial surgery be used to treat the high flow?
Bibliography: Bourquelot (2010), Bourquelot (2009), Tellioglu (2008)

Quality assessment							No. of patients		Effect		Quality	Importance
No. of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Radial artery surgery to treat the high flow	Control	Relative (95% CI)	Absolute		
Primary permeability												
3	observational studies[1]	very serious[1]	no serious inconsistency	no serious indirectness	no serious imprecision	none	-	-	-	-		CRITICAL
Improvement of clinical symptoms												
3	observational studies[1]	very serious[1]	no serious inconsistency	no serious indirectness	no serious imprecision	none	-	-	-	-		CRITICAL
Decreased flow (Better indicated by higher values)												
3	observational studies[1]	very serious[1]	no serious inconsistency	no serious indirectness	no serious imprecision	none	114	-	-	-		CRITICAL

[1] case series