Appendix 1. Network analysis of steal from the anterior circulation

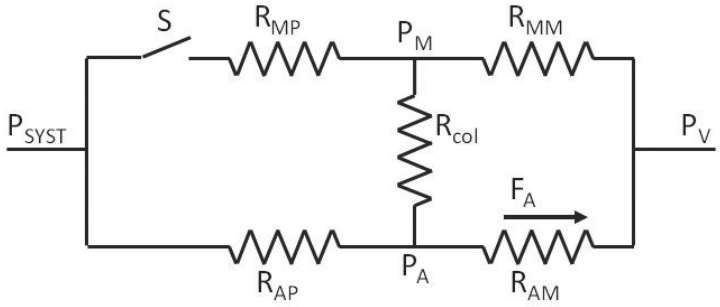

Fig. A1 provides the relevant resistances in the anterior and middle circulation after stroke. Opening of the switch S indicates the onset of stroke in the proximal MCA. The local pressures and flows before onset of stroke depend on the systemic pressure and venous back pressure (respectively P_{SYST} and P_V), resistance in large anterior and MCA branches, proximal to the collaterals (respectively R_{AP} and R_{MP}), the collateral resistance R_{COL}, and the microvascular resistances in both the anterior and MCA perfusion areas (respectively R_{AM} and R_{MM}). After onset of stroke, R_{MP} becomes irrelevant but all other resistances together determine the driving pressure (P_A) for flow through the anterior microcirculation (F_A). Ignoring a possible small collateral flow before the onset of stroke, and taking P_V=0, anterior microvascular flow (F_A) before and after onset of stroke equals:

Before stroke onset:

$$F_A = P_{SYST} \cdot \frac{1}{R_{AP} + R_{AM}}$$

After stroke onset:

$$F_A = P_{SYST} \cdot \frac{R_{MM} + R_{COL}}{(R_{MM} + R_{COL} + R_{AM}) \cdot R_{AP} + (R_{MM} + R_{COL}) \cdot R_{AM}}$$

The anterior microvascular resistance is subject to autoregulation. It is well known that a reduction of systemic pressure causes vasodilation in order to maintain perfusion. Likewise, in this setting, a sudden drop in anterior driving pressure (P_A) at onset of stroke will be compensated by a reduction of R_{AM}. Whether this is sufficient to maintain anterior perfusion at the autoregulatory level depends on the balance of resistances and the reserve in the anterior circulation. The anterior microvascular vasodilator reserve (*MVR*) can be defined as

$$MVR \stackrel{\text{def}}{=} R_{AM}^{reg} \Big/ R_{AM}^{dil} = G_{AM}^{dil} \Big/ G_{AM}^{reg}$$

Where R_{AM}^{dil} is the minimal anterior microvascular resistance, under full vasodilation, and R_{AM}^{reg} the resistance under normal autoregulation, prior to stroke onset. Conductance G is the reciprocal of resistance.

Anterior flow then will be maintained within the autoregulatory range if

$$MVR \geq 1 + \frac{R_{AP}}{R_{MM} + R_{COL}}$$

A few numerical cases illustrate this: If the resistance in the large anterior arteries, R_{AP}, is negligible, no vasodilator reserve is needed to maintain anterior perfusion at the autoregulary level (*MVR*=1). In this case, P_A equals P_{SYST} and the collateral flow is not imposing a load on the anterior circulation at all. Also in the absence of collaterals, *MVR*=1 is sufficient but in this case obviously the anterior and medial circulation are fully separated and there is no collateral flow. If R_{AP} equals the resistance of the collaterals and medial microcirculation (R_{COL}+R_{MM}), *MVR* needs to be at least 2 in order to maintain anterior flow at the autoregulatory level during middle cerebral artery occlusion.