

The *Chimney Rules* for a successful and durable treatment of complex aortic aneurysms by the chimney endovascular technique

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INTRODUCTION

The Jordan Rules was a successful defensive basketball strategy which developed by the Detroit Pistons and aimed to limit the effectiveness of Michael Jordan. The Jordan Rules were effective for the Pistons during their first three playoff meetings with the Bulls. Detroit beat Chicago four games to one in 1988 then defeated the Bulls in six games in 1989 and seven games in 1990. The Pistons won back-to-back 2 championships after eliminating the Bulls and stopping Michael Jordan. In a similar manner, the *Chimney Rules* aim to present in a comprehensive way the needed follow of parameters and key factors in a standardized manner in order to achieve successful and durable treatment of complex aortic aneurysms by the chimney endovascular technique.

The chimney technique after several in vitro studies can be indicated clinically in the emergent setting in ruptured or symptomatic cases when no time for manufacturing is available.¹⁻²⁴ It can also be indicated for elective treatment. The anatomical features include short infrarenal aortic neck (<1.5cm) and hostile neck anatomy when proximal sealing cannot be assured with standard abdominal devices. Also, in case of high tortuosity and calcification of the iliac vessels, precluding fenestrated technology for the treatment of pararenal aortic pathologies due to the risk of misalignment with the visceral vessels.² The chimney technique can be also used in type IA endoleaks caused by migration of previously implanted endograft. A prerequisite to employ chEVAR is to create at least 15mm of proximal sealing zone.³ In case of need to overstent more than 2 target vessels, other complex EVAR techniques shall be considered since the PERICLES Registry experience denote that even though safe and feasible, the incidence of type IA endoleaks, chimney graft occlusions, and ischemic stroke rates is higher compared with the prevailing single chimney evidence.⁴⁻¹³ The presence of extensive thrombus in the aortic arch or occluded subclavian arteries, 5mm or smaller in diam-

eter renal arteries, wide neck diameter of more than 30mm or the lack of enough (20mm) sealing length are limitations for the technique.⁴⁻¹³ The most remarkable lack regarding the use of the chimney technique is the absence of a standardized approach starting from the pre-operative planning, the procedure and follow up.

CHIMNEY RULE 1:

PRE-OPERATIVE IMAGING EVALUATION

High quality preoperative thoracoabdominal and pelvic CTA of 1mm cuts is mandatory to accurately evaluate the anatomy of the aorta and its branches. It allows to understand the arch anatomy and type looking for safe navigation of catheters and sheaths through it in order to avoid cerebral embolization in presence of thrombus or type 3 arch, where the subclavian artery originates lower than the inner aortic curve. Access and reconstruction at a three-dimensional workstation/ program are needed to create centreline pathways and plan device sizing, selection and orientation for implantation. Regarding planning it seems that the chimney graft behaviour depends on the orientation of the renal artery. It seems like the stiffer a stent is, the bigger tendency it would have for the straight in line position. Thus, in downward oriented target vessels the balloon expandable covered stents when used as chimneys would show wide angles compared to the more flexible and mouldable SECS, while in 90° oriented transversely target vessels intending parallel positioning, they would be deployed in a more acute angles having a risk of kinking and stenosis.

CHIMNEY RULE 2:

DEVICE SELECTION

The PROTAGORAS study evaluated the standardized use of the Endurant II endograft (Medtronic, Minneapolis, MN, USA) in combination with the Advanta V12/iCAST (Getinge Group, Mijdrecht, the Netherlands) BECS in the renal arteries of 128 patients.⁴ Consequently, this device combination received European CE mark approval as an on-label indicated therapy for juxtarenal aneurysms.⁴ In addition, use of the Endurant device with the short M-shaped stents allows harmonic adaptability of the device in hostile necks, offering a full expansion of the endograft in 5mm length, covering the aneurysm sac and leading to successful exclusion of the pathologic process. Contemporaneously, the low-profile and flexible introducer system allows the trackability in severe iliac calcifications and

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angulations.¹³

Regarding the chimney grafts, despite the plethora of options, the highest level of evidence has the Advanta V12 (Getinge) following by the Begraft peripheral (Bentley). Use of self-expanding covered stents such as the Viabahn (Gore) has good outcomes only when used with the Gore device as abdominal endograft. However, caution is required for the stainless-steel, balloon-expandable chimney grafts when lining angulated renal arteries with additional placement of flexible bare metal stents.⁵ In those cases, the Münster group observed a high risk of occlusion.⁵

CHIMNEY RULE 3:

OVERSIZING OF THE AORTIC STENT-GRAFT AND LENGTH OF THE NEW SEAL ZONE

The aortic stent graft oversizing is the first key parameter for ChEVAR planning. A 30% main graft oversizing is significantly related to freedom from IaEL-related reinterventions. In case of double chimney grafts and/or hostile neck features, the higher ranges should be planned. A 20-25 mm total neck length should be suggested considering the amount of lost neck, higher in angulated anatomies.¹³ The pararenal and wide necks are significant risk factors for persistent endoleaks. A single parallel graft combination (Medtronic Endurant and Advanta-iCast V12) ensures excellent clinical mid-term outcomes also in hostile aortic necks. Wide necks (>30 mm) were significantly related to IaEL having a mean oversizing (OS) of less than 20%; contrariwise, narrow diameters (<23 mm) were significantly related to CG-stenosis/occlusion.¹³ The presence of infrarenal neck of at least 2mm as in the IFU recommended resulted the only factor preventing IaELs; in case of no infrarenal neck, an oversizing more than 35% is needed in order to minimize the risk of persistent gutters.¹³ Another important finding by Fazzini S. et al¹³ was the estimation of the lost neck, considering that the ideal and available total neck length is not always achieved; even in case of very precise deployment, some portion of neck could be lost after placement of the endograft, caused by the presence of the sheaths in place and/or very angulated anatomy. Due to those reasons, a CTA-based measurement of the seal length in 3 segments including the infrarenal neck if present and the new neck is beneficial.¹³ The mean diameter of these 3 segments should be taken in consideration in order to select the appropriate aortic stent-graft diameter based on the concept of 30% oversizing.¹³ This is very crucial for durable outcomes especially in conical necks with divergence between the proximal and distal neck diameters.

CHIMNEY RULE 4:

PERIPROCEDURAL ISSUES

A kissing-balloon manoeuvre should be always performed using a moulding compliant balloon and the balloons of each balloon-expandable chimney stent inflated to nominal pressure. First, the chimney graft balloon should be inflated followed by inflation of the Reliant balloon within the abdominal endograft. After that, the compliant balloon should be deflat-

ed followed by the deflation of the chimney graft balloon.

Another key point for the procedure should be the protection of the chimney graft balloon shoulder by the sheath. This manoeuvre allows a safe removal of the balloon avoiding any interaction with the pins as a possible cutting of the balloon and trapping the balloon by the pins.

CHIMNEY RULE 5:

Follow please Chimney rule 1,2,3 and 4.

CONCLUSION

The present letter to the Editor aims to review and present in a comprehensive way a more than 12 years published and clinical experience with the chimney endovascular technique in the treatment of complex aortic aneurysms. The view of the author is that the technique has a complementary role with the other total endovascular options and when there is an indication to use it, there is a need to follow rules, exactly like the Detroit Pistons have successfully done, when they planned to stop Michael Jordan, in order to be successful and achieve durable outcomes.

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