CLINICAL RELEVANCE OF THE LEFT BRACHIOCEPHALIC VEIN ANATOMY FOR VASCULAR ACCESS IN DIALYSIS PATIENTS

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BACKGROUND

The arteriovenous (AV) fistula is the preferred vascular access for hemodialysis, but in most patients, an AV is not available at the start of renal replacement treatment, so using a **central venous catheter (CVC)** is necessary and lifesaving.[1] The main options for CVC placement are the use of the right internal jugular vein (RIJV) or the **left internal jugular vein (LIJV)**. While the former is the preferred approach in clinical practice, the latter is considered the next best option in case of RIJV complications such as thrombosis or stenosis.[2,3]

In LIJV catheterization, to reach the right atrium, the CVC must pass through the left brachiocephalic vein (LBV), which also drains blood from the left arm through the subclavian vein. The aim of this study is to address, through new imaging techniques with three-dimensional (3D) reconstruction, the anatomy of the LBV in the context of the central vein catheterization and how it affects vascular access in hemodialysis patients.

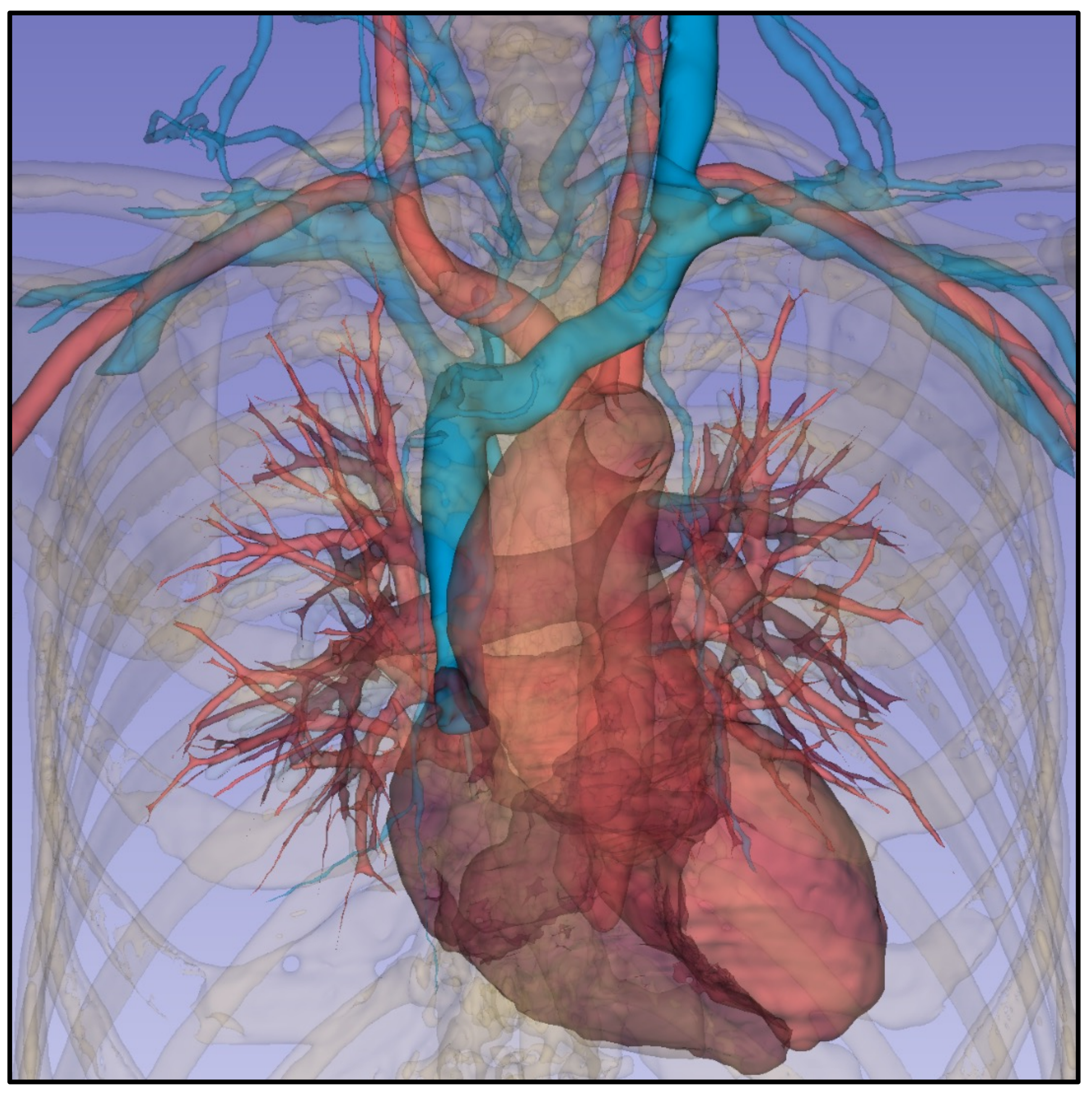

Figure 1 – Tridimensional reconstruction of the left internal jugular vein, left brachiocephalic vein, and superior vena cava of a hemodialysis patient. Frontal view.

MATERIAL AND METHODS

This study involved three patients that had a RIJV CVC removed after the creation of an AV fistula. After its failure, they all received a temporary catheter in the right femoral vein. The central thoracic veins of the three hemodialyzed patients were **three-dimensionally** reconstructed (Figure 1) from 1-millimeter-thick contrast-enhanced computer tomography (CT) scans acquired in venous phase. The CT images were exported as DICOM files and loaded on 3D Slicer, an open-source software for medical imaging visualization and analysis which provides powerful tools for creating 3D patient-specific models through image segmentation.

The **length** of the LBV and the superior vena cava were then measured through a **standard ruler** tool applied to the bidimensional CT scan slices (Figure 2) and through **3D Slicer "curve maker"**, an extension which interpolates in the CT scan the position of a list of fiducial markers placed in the centers of the vessels (Figure 3). The software also allowed to measure the **angulations** between the LIJV and the LBV and the LBV and the superior vena cava, along with the angulation of the LBV when passing between the aortic arch and the sternum, in both the frontal (coronal) and axial (transverse) planes.

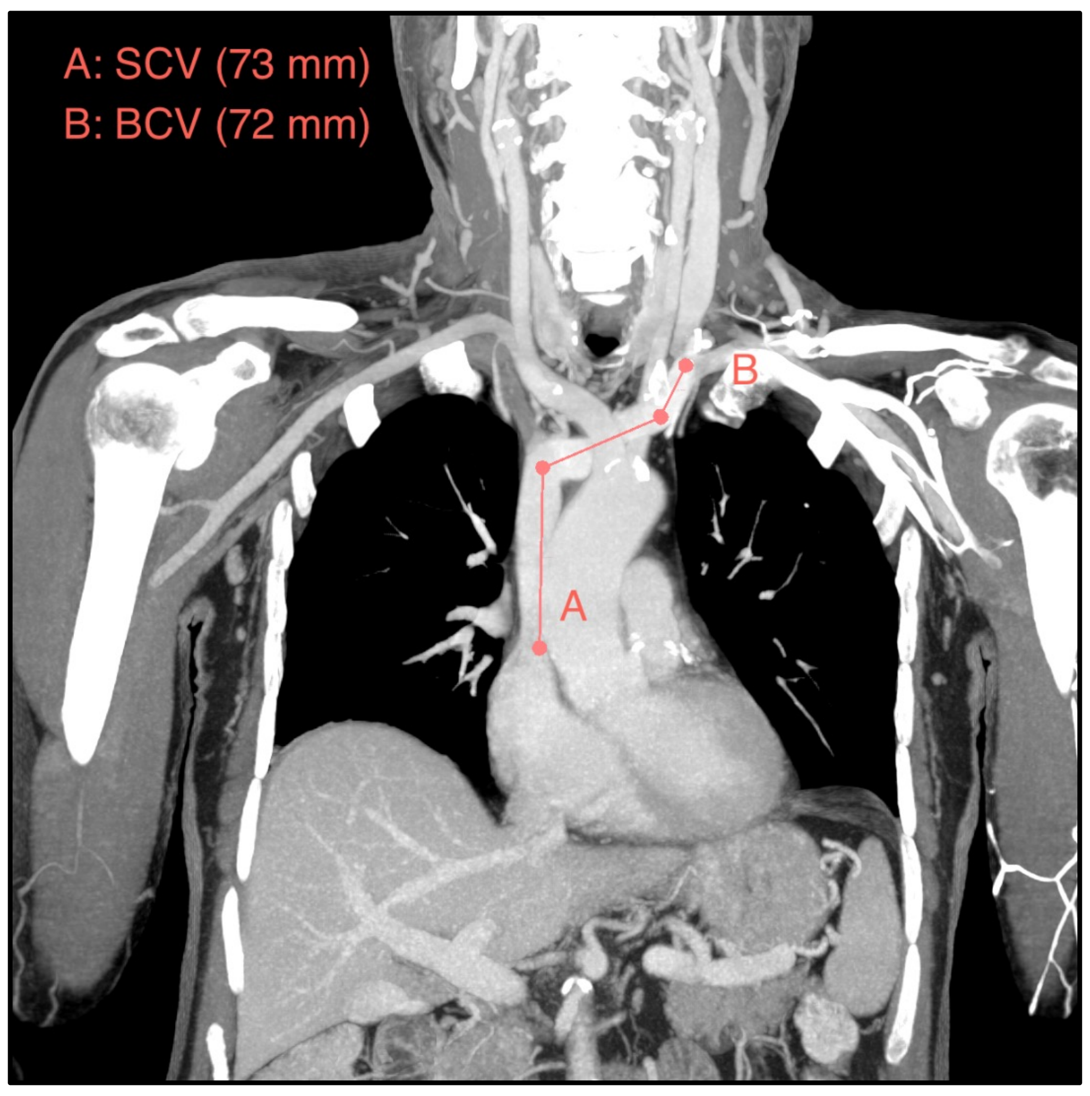

Figure 2 – Measurement of the left brachiocephalic vein and the superior vena cava lengths through a standard ruler tool applied to the bidimensional CT scan slices (145 mm in this case).

RESULTS

The 3D reconstructions performed in this study showed that the LBV has a **tortuous path** with **three main angulations** that could be associated with external compression and stenosis. These could entail difficulties, an increased **risks of venous injury** during CVC placement and of medium to long-term **catheter-associated vein thrombosis and stenosis**.

	Right BCV origin to cava-atrial junction (mm)						Left BCV origin to cava-atrial junction (mm)					
	Linear			3D curve			Linear			3D curve		
	BVC	SVC	Total	BVC	SVC	Total	BVC	SVC	Total	BVC	SVC	Total
Mean	41.1	62.8	**103.9**	45.2	63.3	**108.5**	86.3	62.8	**149.1**	95.3	63.3	**158.6**
SD	3.7	11.5	**15.2**	7.9	11.8	**18.5**	9.8	11.5	**17.6**	8.7	11.8	**17.3**

Table 1 - Distances from the origin of the right and left brachiocephalic veins to the cava-atrial junction.

	LIJV–LBV	Midline crossing	LBV–SVC
Mean	154°	139°	108°
SD	23°	23°	2°

Table 2 - Measured mean (±SD) angulations of the pathway followed by a central venous catheter inserted in the left internal jugular vein (LIJV) and travelling through the left brachiocephalic vein (LBV).

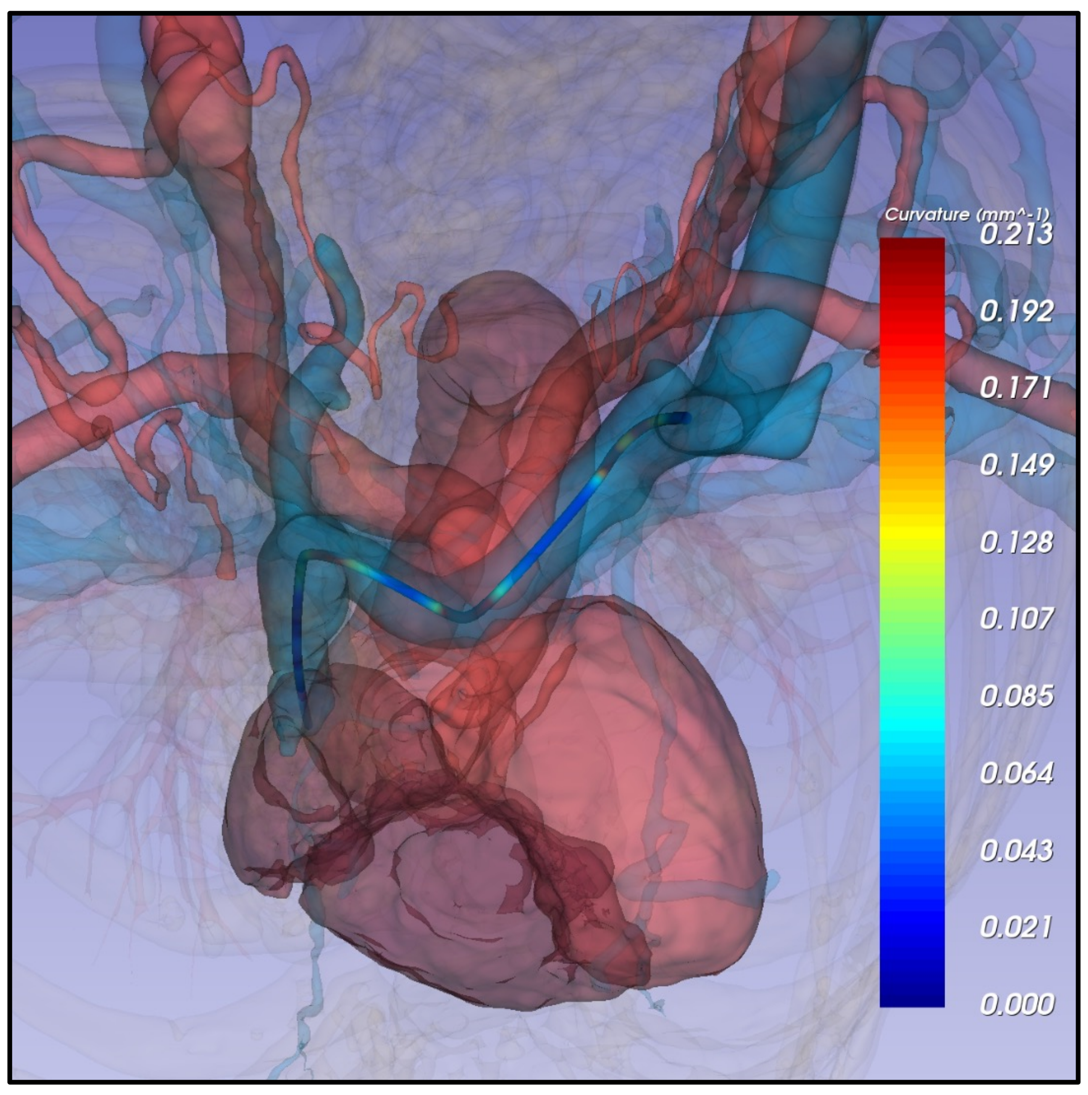

Figure 3 – Measurement of the left brachiocephalic vein and the superior vena cava lengths through 3D Slicer "curve maker" (172 mm in this case). Measurement of the angulations between the left brachiocephalic vein and the superior vena cava, along with the angulation of the LBV when passing between the aortic arch and the sternum.

DISCUSSION

This study challenges the common belief that the right and left internal jugular approaches are similar for hemodialysis CVC placement in their consequences for future AV access. One of the main differences between them is the **nonlinear pathway** from the LIJV to the right atrium through the LBV and superior vena cava.

This study, using **3D patient-specific models reconstructed from CT imaging**, measured the LBV three main angulations that could be associated with external compression and stenosis. These could determine the difficulties and increased risks of venous injury during CVC placement and an increased risk of medium to long-term catheter-associated vein thrombosis and stenosis.[4]

CONCLUSION

The anatomical features of the LBV indicate that the path of a CVC from the LIJV to the right atrium is tortuous and can easily be complicated by vein injury, negatively affecting the creation of future arterio-venous vascular accesses in the left arm. Evidence from our data and from the available literature indicates that **the LIJV should not be considered the second-best option** for hemodialysis CVC placement after the right internal jugular vein.[5] Avoiding cannulation of the subclavian veins and the LIJV in hemodialysis patients with future possibilities of establishing arterio-venous dialysis access should be strongly considered a priority.

REFERENCES

1. Schwab, S. J., & Beathard, G. (1999). The hemodialysis catheter conundrum: Hate living with them, but can't live without them. Kidney International, 56, 1–17.
2. Gallieni, M., Pittiruti, M., & Biffi, R. (2008). Vascular access in oncology patients. CA: A Cancer Journal for Clinicians, 58, 323–346.
3. Kucher, N. (2011). Clinical practice. Deep-vein thrombosis of the upper extremities. The New England Journal of Medicine, 364, 861–869.
4. Agarwal, A. K., Patel, B. M., & Haddad, N. J. (2007). Central vein stenosis: A nephrologist's perspective. Seminars in Dialysis, 20, 53–62.
5. Schmidli, J., Widmer, M. K., Basile, C., De Donato, G., Gallieni, M., Gibbons, C. P., … van Loon, M. (2018). Vascular access clinical practice guidelines of the European Society for Vascular Surgery. European Journal of Vascular and Endovascular Surgery, 55, 757–818.

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