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Transit-time ultrasound technology-assisted lymphatic supermicrosurgery

Dear Sir,

Lymphatic supermicrosurgery, or lymphaticovenular anastomosis (LVA), is increasingly performed for the treatment of lymphedema due its efficacy and minimal invasiveness.[1] When performing the LVA, it is important to select healthy, functioning lymphatic vessels because the procedure relies on establishing a favorable lymph-to-vein pressure gradient.[2,3] To our knowledge, no method currently exists that allows direct intraoperative measurement of the lymphatic flow. Surgeons, therefore, rely on intraoperative visual inspection when selecting the lymphatic vessels. After completing an anastomosis, the anastomotic patency is commonly assessed by visually observing for blood "wash-out" in the vein. This observation is qualitative in nature and can lead to false positive/negative. Transit-time ultrasound technology (TTUT), with its sensitivity reaching 0.01 mL/min,[4] offers potential in measuring the minuscule flow in these microscopic vessels. In this letter, we describe our early experience of using TTUT in this novel application.

Lymphatic supermicrosurgery was performed in two patients — one with Campisi stage IV upper and one with Campisi stage III lower extremity lymphedema, in the standard fashion as was described by Koshima et al.[5] In both cases, the TTUT (Transonic AureFlo, Ithaca, New York) was used via a 0.7 mm probe to measure the lymphatic flow before and after the anastomosis (Figure 1). The mean flow values based on three consecutive measurements were used. The results obtained from the TTUT were compared with surgeon's visual assessments. A total of 28 lymphatic vessels were assessed/measured and 15 LVAs were constructed. The flow in the lymphatic vessels ranged from 0 to 1.2 mL/min, and the flow in the LVAs ranged from 0.22 to 1.4 mL/min. The TTUT measurements consistently correlated with the surgeon's observation in all 28 lymphatic vessels — healthy-appearing lymphatic vessels demonstrated flow values higher than those from unhealthy-appearing lymphatic vessels (Figure 2). Furthermore, all of LVAs with positive "wash-out" had flow $\geq$0.47 mL/min. Interestingly, five LVAs with no "wash-out" on visual examination demonstrated reproducible, measurable flows during TTUT measurements (all $<$ 0.47 mL/min). In 3 LVAs, the pre-existing flows in the lymphatic vessels were "augmented", i.e., demonstrating higher flow values, after the anastomoses. Both patients experienced prompt relief of lymphedema symptoms during the first postoperative week and continued to do well at six months following the surgery.

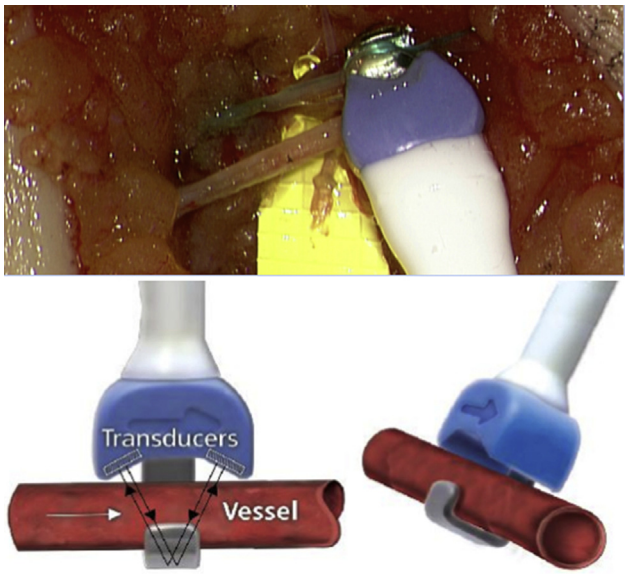

Figure 1 The flow in this 0.4 mm functioning lymphatic vessel was being measured using the 0.7 mm probe. Complete filling the probe well with coupling gel was necessary for proper transduction of signals (top). Mechanism of flow measurement — Transit times obtained from the upstream and downstream transducers were compared to yield flow measurement (bottom, illustration obtained from Transonic AureFlo product brochure with permission, http://www.transonic.com/products/surgical/product/aureflo/).

Based on the above findings, we concluded that the TTUT holds promise in 1) guiding the lymphatic vessel selection, 2) confirming anastomotic patency, and that 3) the absence of "wash-out" may not unequivocally indicate anastomotic occlusion. Further study and higher sample size are necessary to confirm accuracy and reliability of the measurements and correlations between the measurements and varying qualities of the lymphatic vessels.

Financial disclosure and products page

None of the authors has a financial interest in any of the products, devices, or drugs mentioned in this manuscript.

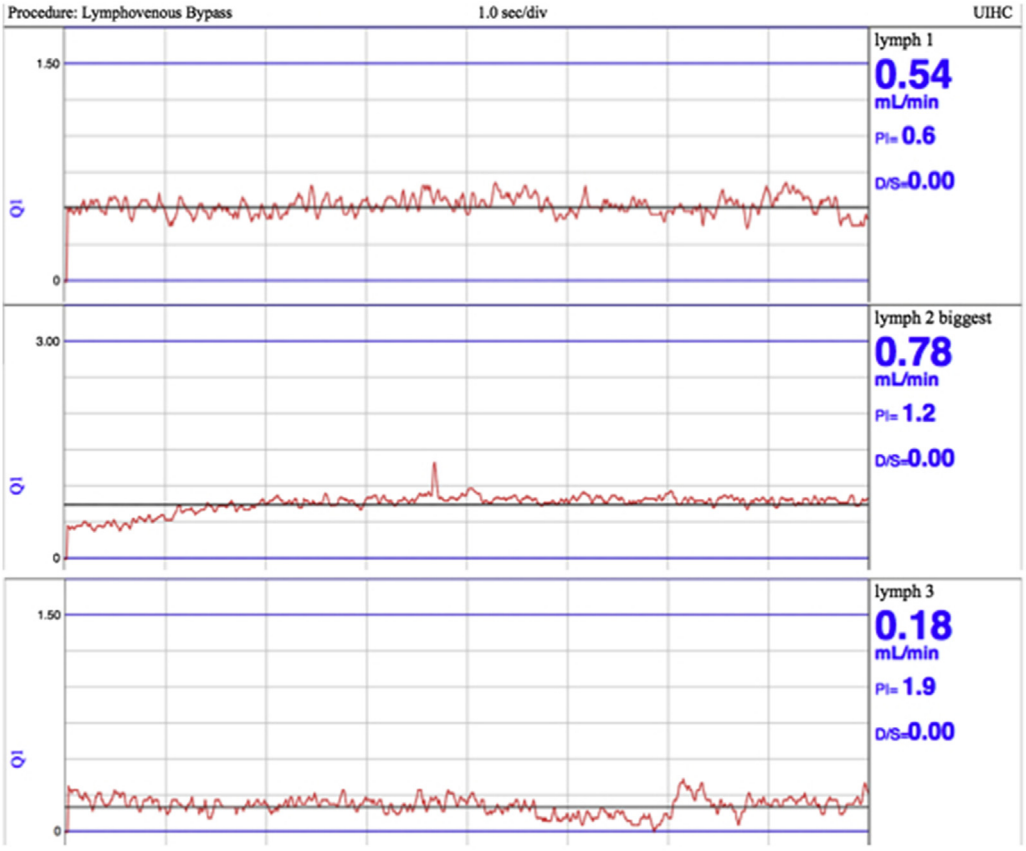

Figure 2 Flows from three lymphatic vessels were measured using TTUT. Lymphatic vessel #2 was the largest and had the highest quality by visual inspection while lymphatic vessel #3 appeared the most sclerotic. The TTUT measurements correlated well with the above clinical findings, with vessel #2 demonstrating the highest flow value. It was selected and used to construct LVA.

Conflict of interest

None.

Statement of authorship

Each person listed as an author has participated in the study to a significant extent.

Statement of originality

This manuscript represents an original contribution and has not been previously published.

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