Burns & Trauma, 2024, **12**, 1–3
https://doi.org/10.1093/burnst/tkae032
Letter to Editor

OXFORD

Computed tomography angiography-guided precise flap surgery: a new strategy for flap selection, mapping and harvesting

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To the editor,

Skin and soft-tissue defects commonly result from trauma, infection, necrosis or major excisional surgery due to various causes. Flap surgery is the method by which these defects are reconstructed and repaired. A major challenge during flap surgery is selecting the appropriate donor site. Vascular supply at donor and recipient sites can vary significantly by individual [1]. In our clinical practice, we have found that computed-tomography angiography (CTA) not only accurately locates vascular structures but also provides high-throughput data on soft-tissue structures at the recipient and donor sites, which can aid in the selection of an optimal flap [2, 3]. Therefore, we have developed a new surgical strategy, precise flap surgery based on CTA, to guide optimal flap selection and preparation.

A total of 217 soft-tissue defect patients, ages 19–72 years, underwent precise flap surgery based on CTA between January 2014 and December 2022. There were 166 males and 51 females. Flap preparation for precise flap surgery based on CTA includes five steps. (1) According to the location, size, shape and characteristics of soft tissue defects, we determined potential donor sites, upper-limb or lower-limb. Defect and potential donor sites were scanned using CTA. (2) We uploaded CTA images to our hospital's Picture Archiving and Communication System (PACS). Perforators were defined when blood vessels were highlighted by contrast and pierced the fascia to supply the subcutaneous tissue. We located the perforator using the bony prominence as the reference point in the PACS system. (3) Selection of the optimal flap followed the principles of traditional flap surgery, including simple to complex, like to like, and economy. If perforators existed around the defect, we chose a pedicled flap; otherwise, a free flap was selected. (4) We preoperatively marked the perforator position, the pedicle length and the flap's relationship with the surrounding tissues at the donor site. (5) We harvested pedicled perforator flaps in accordance with traditional methods. For free flaps, in most cases we adopted antegrade dissection, which could dramatically reduce surgical difficulty and shorten operative duration.

We performed 221 precise flap surgeries based on CTA in 217 consecutive patients. All flaps were harvested successfully. Position, course length, and surrounding structures of perforators and pedicles all followed preoperative planning. There were 152 free flaps and 69 pedicled flaps. Free flaps included 114 anterolateral thigh flaps, 18 superficial lateral sural artery perforator flaps, 6 lateral arm flaps, 4 double paddle deep inferior epigastric perforator flaps, 3 anteromedial thigh flaps, 3 fibular chimeric flaps, 2 anterior tibial artery perforator flaps, 1 latissimus dorsi flap and 1 medial sural artery perforator flap. Pedicled flaps included: 30 peroneal artery perforator propeller flaps; 12 posterior tibial artery perforator propeller flaps; 3 femoral artery perforator propeller flaps; 2 each of retrograde anterolateral thigh flaps, peroneal artery perforator flaps, saphenous neurocutaneous flaps, lateral supramalleolar flaps, sural neurocutaneous flaps and popliteal artery perforator flaps; and 1 each of an ulnar artery perforator flap, medial sural artery perforator flap, deep inferior epigastric artery perforator flap, gracilis flap, medial plantar flap, forearm interosseous artery perforator propeller flap, medial forearm neurocutaneous flap, lateral thoracic perforator flap, thoraco umbilical flap, gastrocnemius VY advancement flap, antegrade anterolateral thigh flap and anterior tibial artery perforator propeller flap. After surgery, 8 and 11 flaps had complete and partial necrosis, respectively. The remaining 202 flaps (91.4%) survived uneventfully.

A 49-year-old man presented with a massive right-heel degloved defect (Fig. 1) that required a double-paddle flap. We scanned potential donor sites on CTA. The ipsilateral deep inferior epigastric artery branched into two perforators (supplementary Video 1, see online supplementary material),

Received: April 22, 2024. **Accepted:** May 16, 2024

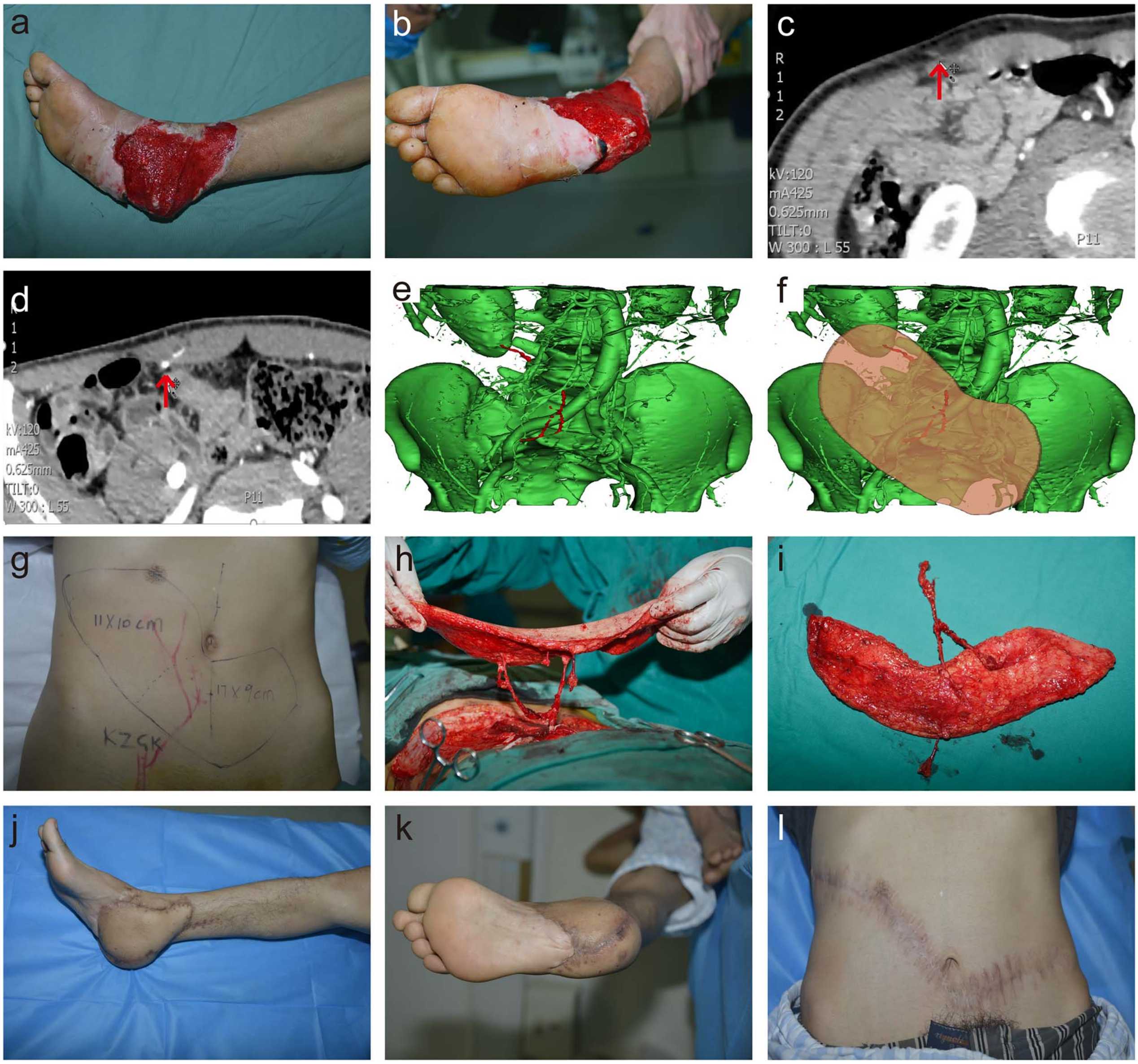

Figure 1. A double-paddle deep inferior epigastric perforator flap was utilized for reconstructing the soft tissue defect in the heel based on CTA. (**a**) Preoperative medial view of the defect. (**b**) Preoperative plantar view of the defect. (**c**) First perforator (the arrow) of the ipsilateral deep inferior epigastric artery on CTA. (**d**) Second perforator (the arrow) on CTA. (**e**) 3D model reconstructed based on the abdominal CTA images, with two red blood vessels showing ipsilateral deep inferior epigastric artery perforators. (**f**) Deep inferior epigastric perforator flap designed as a 3D model according to the defect size and perforator location. (**g**) Double-paddle flap designed based on CTA. (**h**) Harvesting of the flap during surgery based on preoperative planning. (**i**) Harvested double-paddle flap. (**j**) Postoperative medial view, 1 year after surgery. (**k**) Postoperative plantar view. (**l**) Postoperative donor-site view

meeting the requirements of a double-paddle flap, which we designed and harvested. It survived uneventfully after surgery. One-year postoperative outcomes were favorable.

Herein we describe a new surgical strategy, precise flap surgery based on CTA, to facilitate optimal preoperative flap preparation. The key to this new strategy is to accurately assess the defect and potential donor sites based on high-throughput data from the CTA scan. Precise flap surgery based on CTA has three outstanding advantages: precision, efficiency and a simplified procedure.

During traditional flap surgeries, the individual variation of the vascular structures and anatomically disrupted defect site can affect surgical outcomes. In precise flap surgery based on CTA, the surgeon can accurately view the vascular network and overcome the uncertainty caused by individual vascular variations. For example, uncertainty in the source and number of perforators can make it difficult to harvest a double-paddle flap, which is a challenge even for experienced surgeons. In the present study, 15 patients required double-paddle flaps. Based on CTA data, we accurately selected the optimal donor sites after comparing the bilateral anterolateral thigh flap and deep inferior epigastric artery flap before surgery. We designed and harvested 11 anterolateral thigh flaps and 4 deep inferior epigastric artery flaps. All these patients had satisfactory outcomes.

CTA can perform a large-scale scan of the body within a few minutes to provide comprehensive and accurate data on bone, soft tissues and vascularity. Our previous research showed that the specificity of CTA for perforating vessels could reach 100%, with accuracy of 97.4% in 0.8-mm blood vessels and

100% in 1-mm blood vessels [3]. These results were consistent with those of other reports [4].

During traditional flap surgery, a key step is to dissect and harvest the vascular pedicle of the flap, a process that is often tedious. The operation can become more difficult when complicated flaps such as double-paddle, chimeric or flow-through flaps are required. In our study, precise preoperative planning based on CTA measurements could significantly simplify surgery and shorten operative duration. The study included 114 patients who required anterolateral thigh flaps. Of these, 57 (50%) had septocutaneous perforators, a proportion higher than those reported in previous studies [5]. This was because we purposely selected the septocutaneous perforator after evaluating both thighs and other donor sites on preoperative CTA, having determined that this perforator could have better outcomes.

In our clinical practice, we mainly use precise flap surgery based on CTA for orthopedic defect repair in the extremities. Future studies are required to explore its applications in defects of the trunk, head and neck.

Acknowledgments

We are grateful to the Department of Orthopedic Surgery, 920th Hospital of Joint Logistic Supports Force of People's Liberation Army of China, which provided clinical cases to finish this study.

Authors' contributions

Yan Shi (Conceptualization, Software [lead], Writing—Original draft [lead]), Yongyue Su (Validation [lead], Writing—review & editing [equal]), Xi Yang (Investigation [equal], Software [equal]), Jiazhang Duan (Software [equal], Visualization [equal]), and Xiaoqing He (Conceptualization [equal], Investigation [equal], Writing—review & editing [equal]).

Supplementary data

Supplementary data is available at *Burns & Trauma Journal* online.

Ethics approval and consent to participate

This study complied with the rules for human experimentation and has been approved by the Medical Ethics Committee of 920th Hospital of Joint Logistics Support Force of PLA. The registration number is 2022–009-003. All patients provided written informed consent.

Conflict of interest

None declared.

Funding

This study was supported by the Basic Research Project of Department of Science and Technology of Yunnan Province (202101AY070001–298; 202201AY070001–288; 202201 AU070229).

Data availability

All data and materials of the present study were in full compliance with the journal's policy.

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