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ILLUSTRATIVE ORIGINAL SURGICAL VIDEO

Technical nuances for achieving successful STA-MCA bypass anastomosis

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The success of bypass surgery hinges on two key goals: ensuring long-term bypass patency while minimizing ischemic complications by reducing clamping time. While off-the-job training in anastomosis techniques is crucial, it's not enough. Many vital skills—such as preparing the recipient artery and establishing an optimal surgical field—can only be mastered through real surgical experience. This paper shares practical tips and insights from our specific technique. We emphasize the universal principle of performing each step with precision and thoroughly confirming its accuracy before moving on, a discipline essential for successful bypass surgery regardless of the specific school of thought or technique.

Keywords: bypass surgery, end-to-side anastomosis, long-term patency, surgical technique, ischemic complications

Introduction

The most crucial aspect of bypass surgery is achieving long-term patency. A nonfunctional bypass negates the potential benefits of the invasive procedure. Furthermore, because bypass surgery is often prophylactic, avoiding complications is equally critical. Even a technically perfect bypass is rendered useless if temporary occlusion during anastomosis results in, for example, cerebral infarction due to prolonged occlusion time. Therefore, minimizing temporary occlusion time during vascular anastomosis is essential.

In bypass surgery, success depends on achieving both long-term patency through a well-constructed anastomosis and minimizing the duration of temporary occlusion.

While bypass surgery involves numerous steps, successful completion generally depends on meticulous execution of each procedure. Although anastomosis technique can be acquired through off-the-job training, many other crucial steps, difficult to replicate in such settings, require mastery through clinical experience. Indeed, factors beyond the anastomosis technique itself often play a more significant role in bypass surgery outcomes. This paper presents important considerations and tips focused on these non-anastomotic aspects.

Creating an optimal surgical field for anastomosis

The difficulty of performing an anastomosis is highly dependent on surgical field preparation. Even with the same surgeon operating on the same vessels, anastomosis time can vary significantly between a well-prepared surgical field and one with inadequate hemostasis. Once the recipient artery is incised, completing the bypass is generally irreversible. Therefore, anastomosis should not begin until a satisfactory surgical field is established. Furthermore, even after completing surgical field preparation, it is crucial to simulate the planned procedures (e.g., clip application, arteriotomy, and needle manipulation space) and confirm that the planned approach aligns with the actual conditions.

Figure 1 illustrates a case where the author re-established the surgical field setup for a resident who was about to begin anastomosis with an incomplete setup. The initial field setup by the resident (**Figure 1a**) presented several issues:

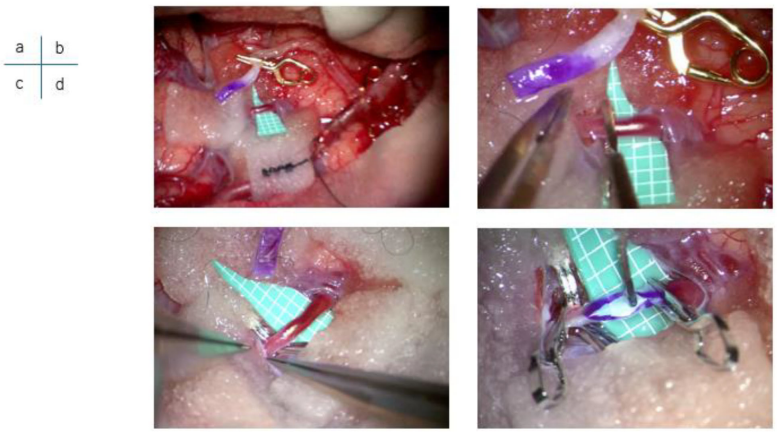

FIGURE 1 | Case of re-establishing surgical field setup by the author for a resident who began anastomosis with an incomplete field setup. In an inadequate surgical field **(a)**, where brain surface protection and hemostasis are insufficient, the recipient artery is poorly dissected, making it difficult to perform a proper arteriotomy after applying a temporary clip **(b)**. Following the author's correction, the recipient artery **(c)** is prepared, allowing for an appropriately sized arteriotomy even after temporary clipping **(d)**.

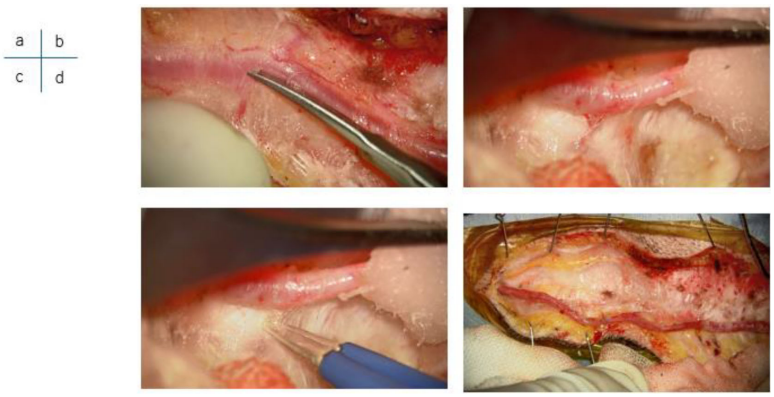

FIGURE 2 | Harvesting STA. Microscissors are used for dissection **(a)**. After identifying the small branch **(b)**, the artery is coagulated with bipolar forceps **(c)**. The harvested parietal branch of the superficial temporal artery (STA) should exhibit minimal bleeding and no thermal damage **(d)**.

1. The temporary clip on the superficial temporal artery (STA) was positioned close.
2. The protection of the brain surface was inadequate.
3. The length of the STA stump and the arteriotomy length on the middle cerebral artery (MCA) were not accurately matched.
4. The STA stay suture needle and thread were placed in a tangled state.

If the anastomosis procedure had proceeded under these conditions, it is crucial to recognize that these incomplete settings would have hindered accurate anastomosis manipulation. This could have led to an extended occlusion time, potentially impacting long-term patency. In this particular case, the first temporary clip was placed under the initial setup (**Figure 1b**). However, it should have been evident that after placing the temporary clip, the arteriotomy length became even shorter, and the space for anastomosis was insufficient.

In the re-established surgical field setup by the author (**Figure 1c**), the arteriotomy of accurate length was ensured even after placing the temporary clip for temporary occlusion, and a sufficiently wide surgical field for anastomosis manipulation was also secured (**Figure 1d**). When applying the temporary clip, it is essential to always be mindful of the direction and angle to maximize the surgical field for anastomosis (**Video 1**).

Superficial temporal artery (STA) harvesting and stump trimming

Long-term bypass patency depends not only on the anastomosis itself but also on the condition of the donor

VIDEO 1 | This video demonstrates the issues with the surgical field created by the resident shown in **Figure 1** and how the author modified that field to achieve a favorable surgical field.
https://youtu.be/ilj-mXtOBVw

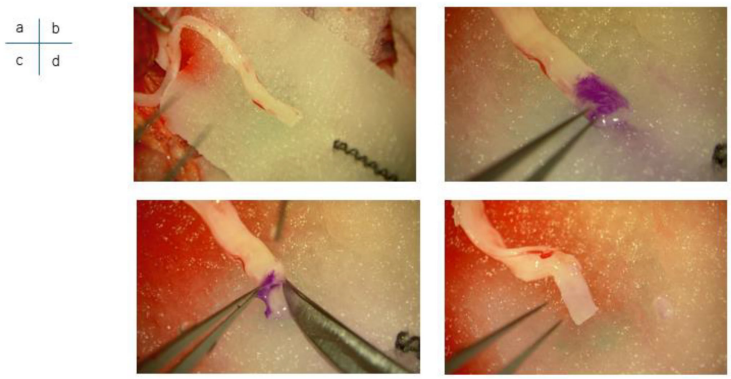

FIGURE 3 | Removal of connective tissue from the STA stump. When the boundary between the connective tissue and the adventitia is unclear **(a)**, applying a thin layer of pioctanine to the stump **(b)** selectively stains the connective tissue, clarifying the boundary **(c)** and facilitating its removal **(d)**.

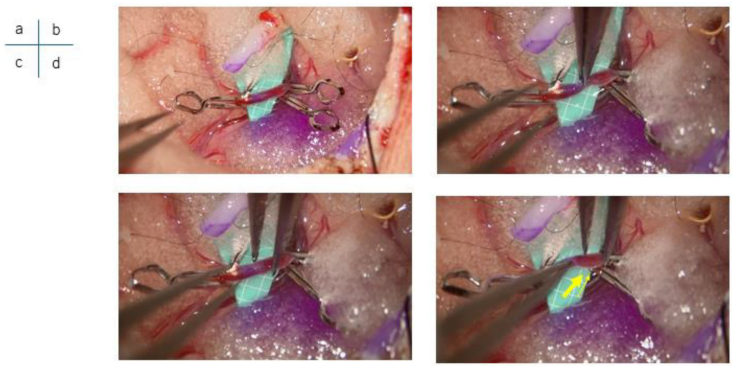

FIGURE 4 | Confirmation of complete temporary occlusion. After temporarily clipping the recipient artery **(a)**, it is essential to check the vessel tension to confirm complete occlusion before proceeding to the arteriotomy step **(b)**. In this case, incomplete occlusion was suspected **(c)**, and it was later found that a small branch between the clip sites remained patent **(d)**.

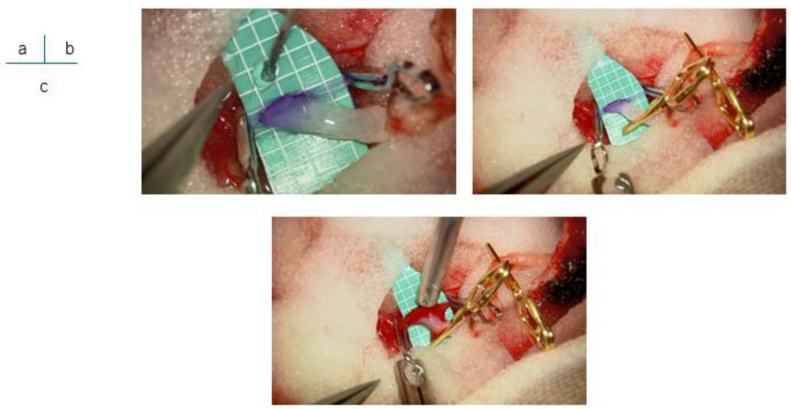

FIGURE 5 | Before releasing the occlusion clips after anastomosis **(a)**, it is crucial to occlude the STA near the anastomotic site **(b)**. This step prevents backflow into the STA. If the anastomosis is incomplete and requires further suturing **(c)**, this backflow may lead to thrombus formation within the STA, delaying the return of normal STA flow.

artery (STA). Harvesting a healthy STA is crucial. We perform dissection between the connective tissue and the adventitia using bipolar forceps with a high-power coagulation mode. This technique facilitates identification of small branch vessels from the STA, allows for reliable hemostasis, and reduces the risk of vessel torsion and kinking compared with methods that preserve the surrounding connective tissue. Moreover, because this dissection plane is relatively avascular, dissection is generally possible without coagulation. Instead of indiscriminately applying coagulation, focusing it only on the branch vessels is vital for avoiding thermal injury to the STA.

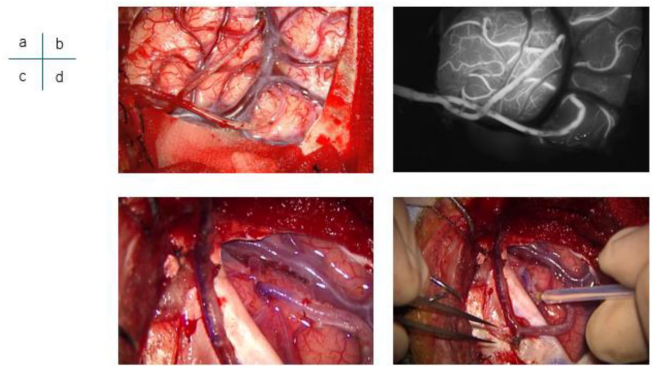

FIGURE 6 | Confirmation of anastomosis patency can be performed using indocyanine green (ICG) video angiography **(a, b)** or Doppler ultrasound **(c, d)**.

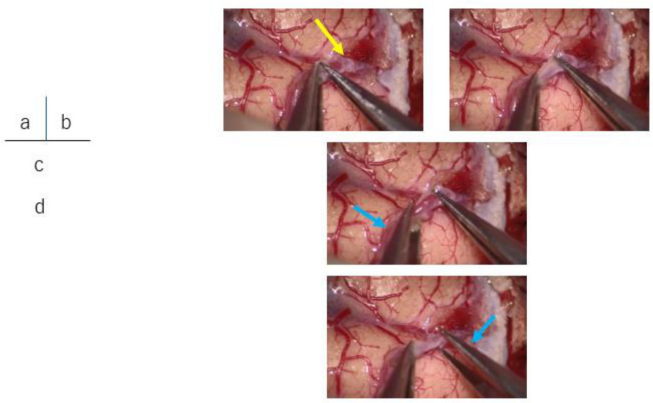

FIGURE 7 | Squeeze technique. The squeeze technique **(a, b)** allows for the confirmation of good STA flow **(c)** and poor anastomosis patency **(d)**.

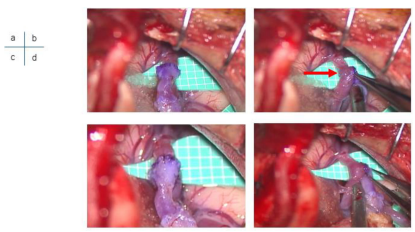

FIGURE 8 | A case of the posterior wall of the vessel being inadvertently caught in the suture during vessel anastomosis. Although the appearance after completing the anastomosis seems adequately expanded **(a)**, inspection of the underside reveals a dimple, indicating that one suture has inadvertently included the posterior wall **(b)**. After re-suturing, the external appearance remains unchanged **(c)**, but the underside confirms sufficient expansion **(d)**.

Recently, we have transitioned to a technique using scissors for dissection instead of bipolar forceps. In this method, branch vessels are identified, coagulated, and then transected (**Figure 2**).

Adequate trimming of the STA stump, with thorough removal of the connective tissue, facilitates the anastomosis procedure. However, in cases with a thin STA, the dissection plane between the connective tissue and the adventitia can be difficult to discern (**Figure 3a**). Applying a thin layer of pioctanine to the vessel wall enhances visualization, as the dye stains the connective tissue more intensely (**Figure 3b**). This allows for clear identification of the correct dissection plane (**Figure 3c**) and enables precise removal of the connective tissue (**Figure 3d**).

Reconfirmation at each step from anastomosis initiation to completion

From the initiation to the completion of the anastomosis, each step is irreversible, making it crucial to ensure flawless execution at every stage, free from any hindrance. Continuous verification of procedural correctness is essential. Several key points are considered important and are described below.

Confirmation after applying temporary clip

After applying a temporary clip for temporary occlusion (**Figure 4a**), confirming complete occlusion before performing the arteriotomy is essential. This can be assessed by grasping the occluded vessel with forceps (**Figure 4b**) and evaluating the vessel's tension and the degree of recoil upon releasing the forceps (**Figure 4c**). Incomplete occlusion

may be due to an unrecognized branch at the occluded site (**Figure 4d**) or insufficient closing pressure of the clip. These possibilities should be investigated and corrected to ensure complete occlusion.

Occlusion of the STA before releasing temporary clip in the recipient artery

Before releasing the occlusion clips upon completion of the anastomosis, it is essential to occlude the STA with a temporary clip near the anastomotic site (**Figures 5a**, **b**). If the STA is not occluded, blood flow from the MCA will flow retrogradely into the STA after the clips are released. While this is not problematic if STA blood flow can be immediately restored, an incomplete anastomosis with significant bleeding may require additional suturing. This can delay STA blood flow restoration, potentially leading to thrombus formation and subsequent STA occlusion due to the retrograde flow. Temporarily clipping the STA initially prevents this retrograde flow (**Figure 5c**).

Squeeze technique to confirm bypass patency

Following completion of the bypass, confirmation of patency is typically achieved using indocyanine green (ICG) video angiography or Doppler ultrasound (**Figure 6**).

Visual assessment of vessel pulsation alone is insufficient. When these methods are unavailable, the "squeezing technique" described below may be useful.

Initially, the STA is grasped with two forceps near the anastomosis (**Figure 7a**) and gently squeezed side-to-side for several millimeters to create a collapsed segment (**Figure 7b**). Subsequently, one forceps is released. Rapid refilling of the vessel with blood flow indicates favorable patency from that point (**Figure 7c**). Specifically, robust backflow from the anastomosis upon releasing the forceps on the anastomotic side suggests good bypass patency. Absent backflow indicates bypass occlusion (**Figure 7d**).

If a patency issue at the anastomosis is identified, determining the cause and promptly performing re-anastomosis or other necessary interventions is essential (**Video 2**).

Confirmation of the anastomosis after releasing occlusion

After completing the anastomosis, the temporary occlusion is released, and STA blood flow is restored. A correctly performed anastomosis will result in a fully dilated anastomotic site. However, even a single misplaced suture can lead to thrombus formation and occlusion, even with initially observed blood flow. Therefore, careful inspection of the suture line is crucial. Any puckering or inadequate dilation, suggestive of a stitch through the back wall. Even if the anastomosis appears superficially dilated (**Figure 8a**), a stitch through the back wall may still be present (**Figure 8b**). After re-suturing, the external appearance remains unchanged (**Figure 8c**), but the underside confirms sufficient expansion (**Figure 8d**). Confirmation of complete dilatation of the MCA's back wall is essential (**Video 3**).

VIDEO 2 | This video demonstrates the actual method of the squeeze technique used to confirm bypass patency.
https://youtu.be/9ugqUkLnq14

VIDEO 3 | This video demonstrates the actual content shown in **Figure 8**.
https://youtu.be/H6EIMQN7Om4

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Conflict of interest

The authors declare no financial or personal relationships with any organizations that could inappropriately influence the content of this article. The mention of specific brand names or products is solely for accurate identification of the surgical instruments used and does not imply endorsement of one product over another.

Conclusion

Mastery and implementation of bypass surgery require off-the-job training in microsurgical anastomosis techniques. However, the steps involved in setting up the surgical field before initiating the anastomosis and confirming the implemented procedures are even more critical. Reliable execution of these steps enables safe completion of a bypass with long-term patency.