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Management strategies of intercavernous sinus bleeding during transsphenoidal surgery

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Abstract
Background Transsphenoidal surgery has been well established as an effective primary treatment for tumours of the sellar region. During the dural opening, the prominent intercavernous sinus poses limitations for this approach and may contribute to incomplete tumour resections.
Method Based on our experience from 940 cases of conventional transsphenoidal surgery, we have developed a stepwise protocol for achieving bleeding control in 72 cases (7.7%) that had prominent anterior intercavernous sinus.
Findings A custom-made 45-degree right- or left-angled bipolar coagulator (38 cases) or Landolt bipolar coagulator (29 cases; Aesculp, Tuttlingen, Germany) was inserted into the small dural opening, and both of the dural layers were coagulated together so that the potential space between the endoosteal layer and meningeal layer could be sealed, and the dural opening could be extended. When the anterior portion of the medial wall of the cavernous sinus was accidentally opened, we then placed a small piece of oxidised regenerated cellulose (Surgicel; Johnson & Johnson, North Yorkshire, UK) at the opening of the medial wall of the cavernous sinus and coagulated both dural layers together starting from the sellar floor side with a custom-made 45-degree angled bipolar coagulator. For the relatively large opening of the cavernous sinus, a microfibrillar collagen haemostat (Avitene; MedChem Products, Woburn, MA) or fleece-coated fibrin glue (TachoComb; Nycomed Austria, Linz, Austria) patch was applied over the opened cavernous sinus with gentle compression and was found to be effective in most cases. Rarely, direct suture of the opened medial wall of the cavernous sinus was necessary in five cases.
Conclusions We describe a stepwise approach to overcome unusual bleedings from the prominent intercavernous sinus during conventional transsphenoidal surgery. Our surgical experience reveals that these methods can be very effective for the control of sinus bleeding.

Keywords Transsphenoidal approach · Cavernous sinus · Intercavernous sinus · Technique

E.H. Kim and J.Y. Ahn contributed equally to this work.

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Introduction

The conventional transsphenoidal approach has been traditionally adopted as surgical treatment of choice for sellar or intra-suprasellar infradiaphragmatic lesions [6]. Currently, it is the preferred approach for lesions confined to the sellar and parasellar lesions, and in some cases lesions of the clivus as well. During transsphenoidal surgery, a wide anterior sphenoidotomy is performed to expose the bony landmarks of the sellar floor, cavernous sinus, and the optic and carotid protuberances [2]. A high-speed air drill and Kerrison punches can be used to open the sellar floor to the limits of the cavernous sinus laterally and tuberculum sellae superiorly. After completing the opening of the bone window, which depends on the nature and exact location of the tumour, the initial dural opening was made in the sellar dura. Enough of a dural opening is created to allow for direct visualisation of the tumour in the intrasellar space; however, the prominent intercavernous sinus poses limitations for this conventional approach. Therefore, an inadequate dural opening may result in incomplete tumour resection.

In this report, we describe a stepwise approach of bleeding control of the prominent anterior intercavernous sinus for achieving a maximally wide exposure of the intrasellar structures for complete tumour resection.

Technique

Using the principle of the conventional transsphenoidal approach, we usually exposed the dura mater on the anterior surface of the sellar from the floor up to the tuberculum sellae (or diaphragm) superiorly and both medial walls of the cavernous sinus laterally. In the majority of cases, anterior intercavernous sinuses were observed, and inferior intercavernous sinuses were not uncommon. If there was enough space between these two sinuses or there was no significant development of the intercavernous sinuses, a conventional dural incision was made. However, if we occasionally encountered an intercavernous sinus covering the whole anterior surface of the

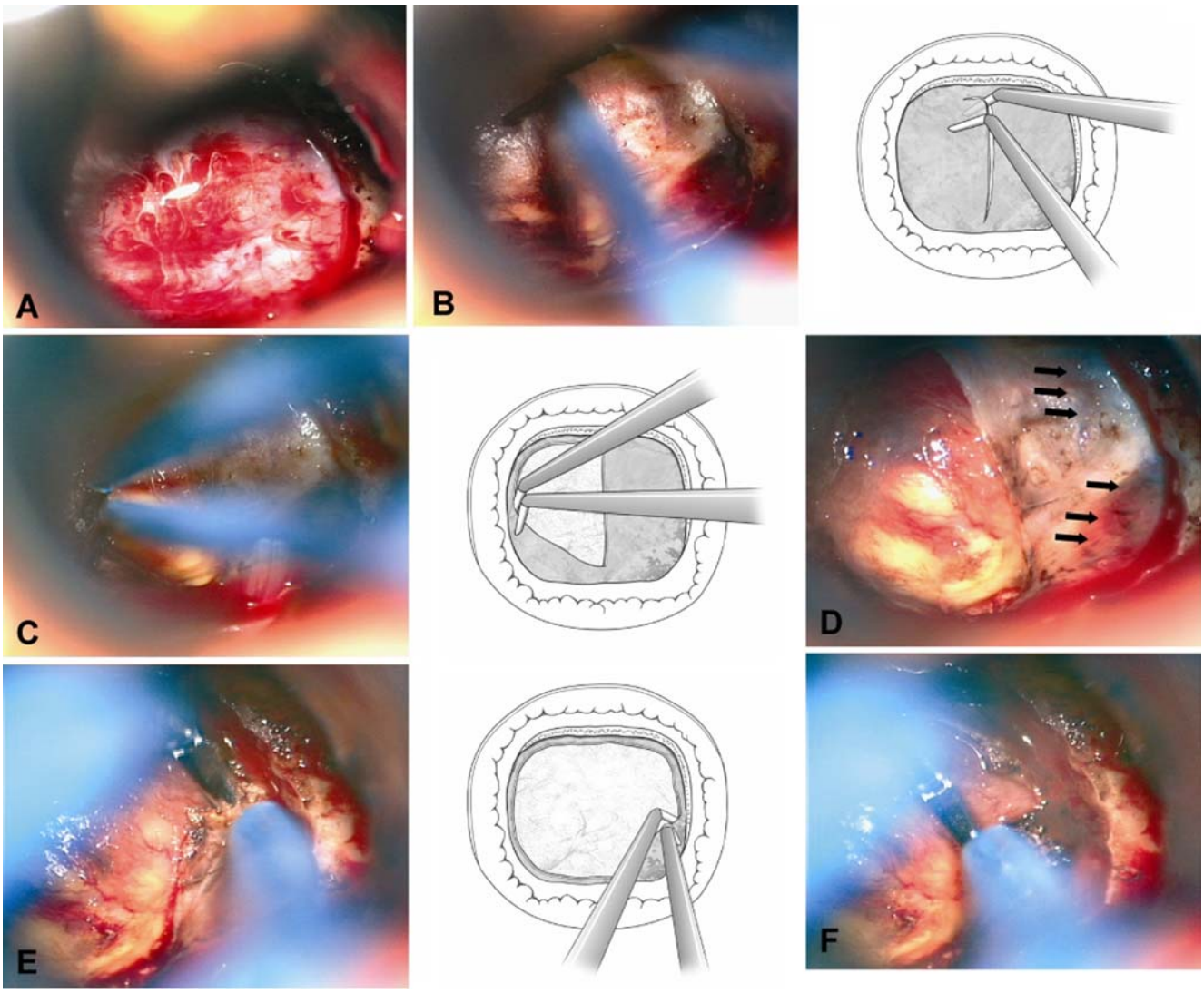

Fig. 1 A 47-year-old male patient with growth hormone-secreting tumour. Opening of sellar floor dura, which had well-developed intercavernous sinus with 45-degree angled bipolar coagulator. (**a**) Sellar floor dura was exposed. A well-developed intercavernous sinus covered the whole anterior surface of the exposed dura mater. (**b**) First, a small vertical incision was made through both of the dural layers at the midline. Through this small dural incision, a custom-made 45-degree left angled bipolar coagulator was inserted, and the two dural layers were coagulated together, so that the potential space between the endoosteal layer and the meningeal layer could be sealed. Then dura coagulation was extended upward and counterclockwise. (**c**) Dural coagulation was extended to the right side. We did not always need to cut the coagulated dura mater because it could be shrunk with coagulation. (**d**) The operative microscopic view showed that the right half of sellar floor dura was completely open without any bleeding from the intercavernous sinus. Well-developed intercavernous sinus was seen at 1 to 3 o'clock and 3 to 5 o'clock side (arrows). (**e**) With the same method, dural coagulation was extended to the left half of the sellar floor dura. (**f**) Final coagulation of the remaining dura on the left lower corner of the sellar floor dura, which had a well-developed intercavernous sinus

exposed dura mater, we applied a different method of dural opening for more careful sinus manipulation.

Based on our experience from 940 cases of conventional transsphenoidal surgery operated by single neurosurgeon (S.H. Kim), we applied a stepwise approach for achieving bleeding control in 72 cases (7.7%) that had prominent anterior intercavernous sinus. We used an angled bipolar coagulator technique in 38 cases (53%) and Landolt bipolar coagulator technique in 29 cases (40%). The direct dural suture technique was used in five cases (7%).

First, if we found any small portion of the dura mater that had no sinus underneath it, we made the incision there. In this step, we would make the incision through both of the dural layers and carefully confirm it with a 90-degree angled fine dissector. Through this dural incision, a custom-made 45-degree right or left angled bipolar coagulator (Fig. 1) or Landolt bipolar coagulator (Aesculp, Tuttlingen, Germany; Fig. 2) was inserted into the small dural opening, and the two dural layers were coagulated together so that the potential space between the endoosteal layer and the meningeal layer could be sealed (the so-called coaptation procedure). After making this small hole in the dura mater, we started to enlarge the hole by coagulation and cutting with custom-made 45 degree angled bipolar coagulators or

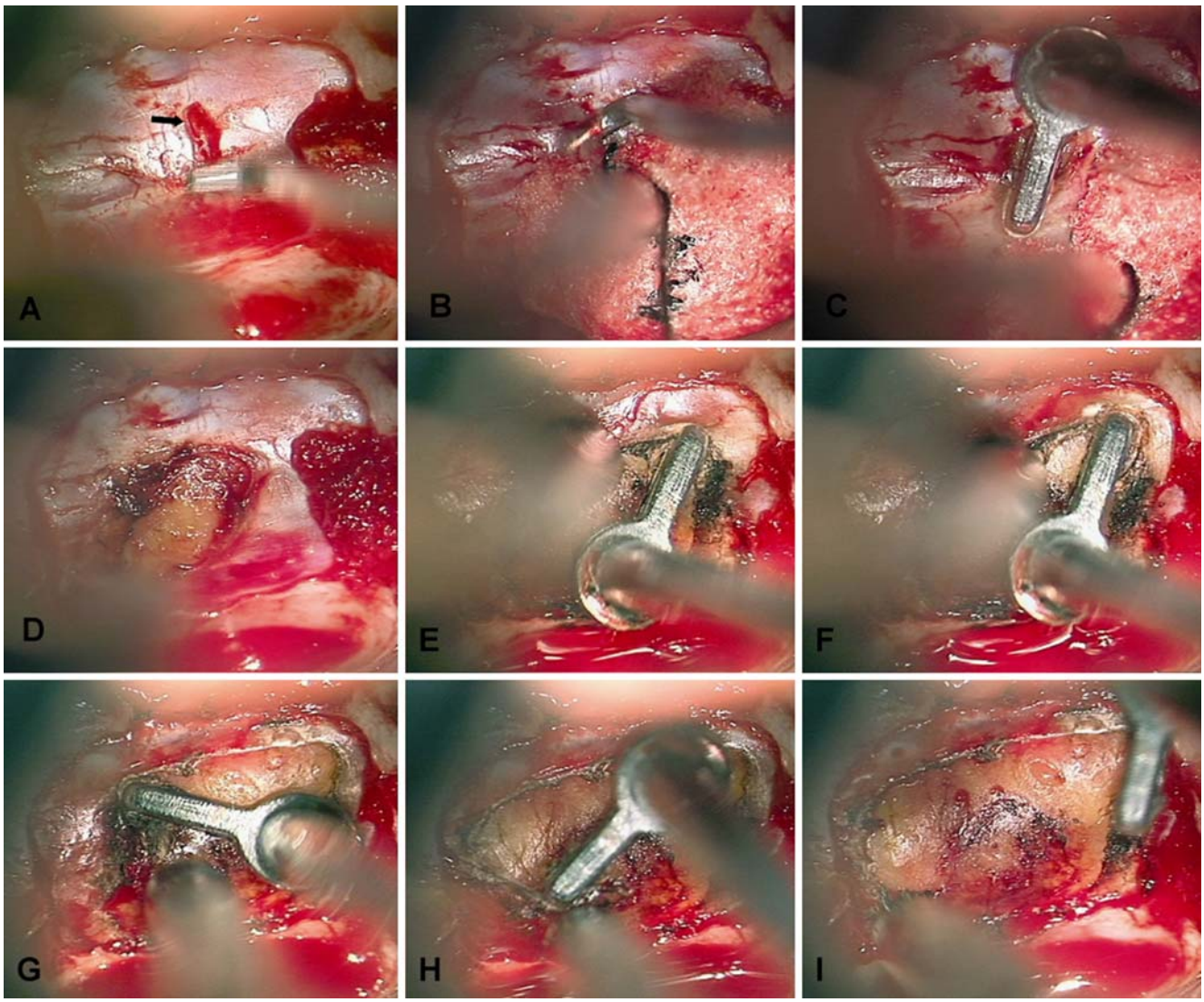

Fig. 2 A 52-year-old female patient with growth hormone-secreting tumour. Opening of sellar floor dura, which had well-developed intercavernous sinus with Landolt bipolar coagulator. (**a**) Sellar floor dura was exposed. A well-developed intercavernous sinus covered the inferior surface of the exposed dura mater. A small vertical incision (arrow) was made on the dura at the portion that had no sinus underneath it. (**b**) Using a 90-degree angled fine dissector, the surgeon carefully confirmed both dural layers were opened. (**c**) The two dural layers were coagulated together with a Landolt bipolar coagulator so that the potential space between the endoosteal layer and the meningeal layer could be sealed. (**d**) After partial coagulation of the sellar floor dura with a Landolt bipolar coagulator, there was no bleeding from the intercavernous sinus, even though the intercavernous sinus was coagulated. (**e**–**h**) The dural opening was extended in concentric fashion. (**i**) Final view of the dural opening without bleeding from the intercavernous sinus

Landolt bipolar coagulators. We did not always need to cut the coagulated dura mater because it could be shrunk with coagulation. This procedure was performed in a concentric, circular fashion. Theoretically, this procedure does not allow for any opening of the intercavernous sinus, which results in minimal blood loss in most of the cases.

When approaching the medial wall of the cavernous sinus, the technique was performed with greater care. Usually, at the junction between the intercavernous sinus and cavernous sinus, the gap between the two dural layers mimics the shape of a triangle; the intercavernous sinus forms the apex and the cavernous sinus forms the base. The gap between the two dural layers could be fairly wide at the point where the intercavernous sinuses merge into the cavernous sinus.

Occasionally, the gap between the two dural layers was opened, and severe bleeding was observed. In this situation, the previously mentioned technique would be inefficient for sealing off these two dural layers. In these circumstances, we first placed a small piece of oxidised regenerated cellulose (Surgicel) at the opening of the medial wall of the cavernous sinus and coagulated both of the dural layers starting from the sellar floor side and continuing to the cavernous sinus side with a custom-made 45-degree angled bipolar coagulator. In the majority of cases, it worked very effectively. However, if this procedure was not effective, a small piece of microfibrillar collagen haemostat (Avitene) was placed over the opened cavernous sinus wall, and then a small piece of cottonoid was applied, followed by firm pressure for several minutes, and then irrigation with saline. The majority of bleeding can be stopped with these steps. Recently, we used fleece-coated fibrin glue (TachoComb) pieces instead of avitene. It also worked very well for stopping the bleeding.

In situations in which all of the previously described techniques failed, a direct suture technique was introduced. One or two stitches with 7-0 Pronova (7.6 mm, 3/8 circle needles, Ethicon, Somerville, NJ) were made with a specially designed suture instrument, which had a similar shape to that of the commercially available 2-mm micro-pituitary forceps [1]. With this instrument, the two dural layers could be sealed off tightly (Fig. 3).

Discussion

Intercavernous sinuses are venous interconnections between the bilateral cavernous sinuses. The dural membrane on the sellar floor is composed of two layers; one is an endoosteal layer that covers the sphenoid bone, and the other is a

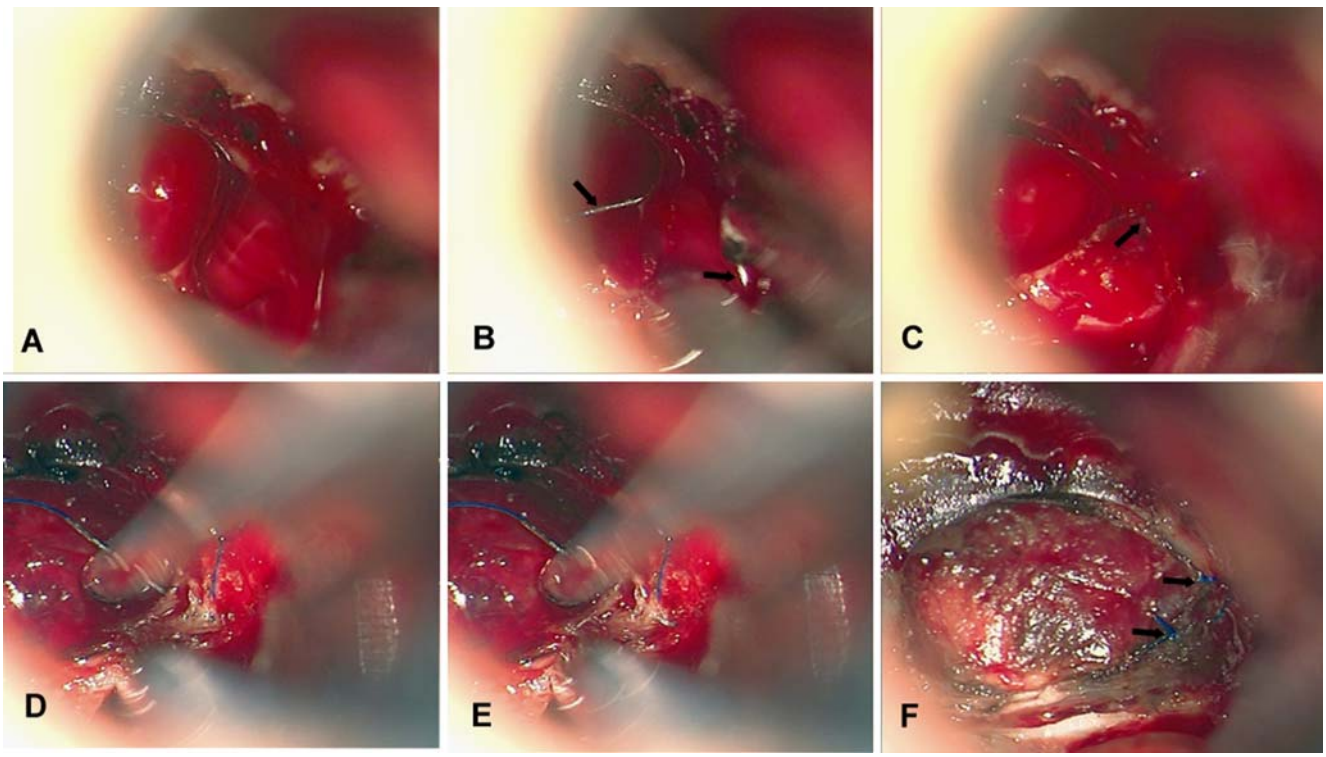

Fig. 3 A 24-year-old female patient with prolactin-secreting tumour. Direct suture of opened cavernous sinus wall. (**a**) Profuse bleeding was encountered from the left anterior wall of the cavernous sinus. (**b**) The suture needle (arrows) was passed through the two layers of the cavernous sinus wall from inside to outside. (**c**) The first suture knot (arrow) was made on the outside wall of the cavernous sinus. Bleeding was almost stopped. (**d** and **e**) The needle for the second suture passed through the inner and outer wall of cavernous sinus. The opened cavernous sinus cavity was well visualised. (**f**) After making two stitches (arrows), bleeding was completely stopped

meningeal layer that faces the pituitary gland. These two dural membranes are easily detached from each other, and in the majority of cases, intercavernous sinuses normally exist in this potential space between the two layers. Occasionally, these venous channels can be found throughout the floor of the sellar turcica and therefore are the so-called circular sinus.

The anterior and posterior intercavernous sinuses are usually compressed and obliterated in patients with macroadenoma, making the dural incision bloodless in a linear, rectangular or cruciate fashion. However, in patients with microadenomas, the exposed sellar dura may be covered by one or two venous channels, which can bleed during the dural incision. To avoid such an event, a small dural incision is initially performed until the venous sinus is reached. Then the intercavernous sinus is secured and sealed with bipolar coagulation forceps or with two small surgical clips placed across it, and the dura then can be safely incised [2, 4]. Otherwise, only the outer wall of the intercavernous sinus is longitudinally incised initially, and both sides of the sinus are packed with oxycellulose before the complete dural opening process [5]. Sometimes, Floseal (Baxter Biosciences, Vienna, Austria) haemostatic gel is used to close the sinus with the bipolar forceps [3]. Even though previously described techniques have been applied, infrequently, in cases in which the intercavernous sinus covers the entire anterior wall of the sella, its management can be problematic and cause the operation to be longer, increase the blood loss and make the access to the intradual compartment more difficult.

Based on our experience from 72 cases that had prominent anterior intercavernous sinuses, we propose management strategies for controlling the intercavernous sinus bleeding during transsphenoidal surgery (Fig. 4). We thought it would be more ideal if we adopted a technique that did not allow any chance of intercavernous sinus opening. Our method is based on this idea, and it did not actually result in much sinus bleeding in our surgical cases. In our method, the most important technical tip is that both of the dural layers should be incised at once, so that the custom-made 45-degree angled bipolar coagulator or Landolt bipolar coagulator can enter through the opening of the two dural layers. Even though only the endoosteal layer was incised, there could be no bleeding if the initial incision was made on sinus-free dura mater. However, as the incision is extended to the nearby dura mater, it reaches the intercavernous sinus, and the bleeding can be unmanageable. So, right after the initial incision is made, it should be confirmed very carefully with a 90-degree angled fine dissector that both of the dural layers are punctured.

The more laterally the dural opening is extended, the wider the gap between the two dural layers becomes. Theoretically, it is almost impossible to control the sinus bleeding by means of sealing these two dural layers. If such a bleeding situation occurred, we placed a small piece of Surgicel into the gap between the two layers. If the gap was relatively narrow, these two layers could be sealed off. Moreover, an Avitene or TachoComb patch applied over the opened cavernous sinus with gentle compression is effective in most cases. Finally, if all of the previous methods failed, a direct suture technique was introduced. Although the direct suture technique is difficult when applied to this narrow and deep space, it may be the ideal method for the control of cavernous sinus bleeding. However, it does require much practice outside of the operating room before attempting a trial in the operating room.

Conclusions

Controlling the bleeding of the vascular channel at the intercavernous sinus of the sellar region is often very

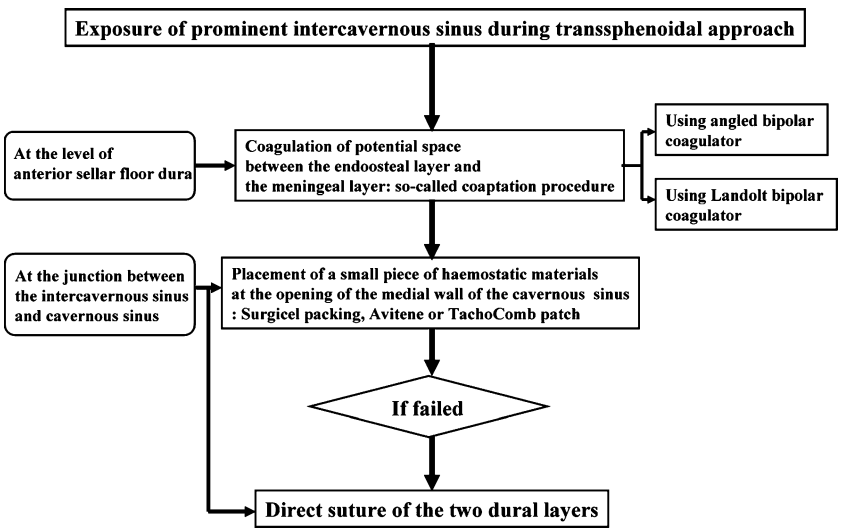

Fig. 4 Proposed management strategies for the control of intercavernous sinus bleeding during transsphenoidal surgery

challenging during the transsphenoidal approach. We adopted different methods for the opening of the dura in cases with a prominent intercavernous sinus. Our surgical experience reveals that these methods can be very effective for the control of sinus bleeding.

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