Check for updates

Gelatin Paste as an Alternative Cost-Effective Hemostatic Agent in Cranial Surgery: Doing More with Less

Juan Leonardo Serrato-Avila[1], José Omar Navarro-Fernández[2], Rodrigo Hernández-Reséndiz[3], Bernardo Cacho-Díaz[2], Gervith Reyes-Soto[2], Alejandro Monroy-Sosa[2]

■ OBJECTIVE: **To present an alternative cost-effective hemostatic agent (HA) for cranial surgery and to describe the technique to produce it.**

■ METHODS: **This HA has been used in 3 reference centers over the last year during 230 procedures, including different types of pathology, such as skull base, oncology, vascular, and trauma, either for endoscopic or open approaches. This agent was made from a low-cost and worldwide-available gelatin foam which was mixed with saline solution in 2 syringes and connected by a 3-way stopcock, making a useful hemostatic paste.**

■ RESULTS: **The cost was 16 and 28 times less than SURGIFLO and FLOSEAL, respectively. The mean time to prepare the mix was 4 minutes. It was very effective for venous and low-flow bleeding.**

■ CONCLUSIONS: **The presented technique offers a reliable and cost-effective way of achieving hemostasis in cranial surgery, therefore allowing hospitals with limited resources to perform advanced procedures in a safer way.**

INTRODUCTION

Intraoperative bleeding is one of the most common and life-threating complications in neurosurgery, which can lead to important neurologic deficits and even death, with severe costs for the health system.[1] There are several hemostatic agents (HAs) in the armamentarium of the neurosurgeon to address this problem, such as cellulose derivates, gelatin, collagen, thrombin, fibrin glue, aldehyde glues, polysaccharide arista, and gelatin-thrombin matrix.[2] Most of them are expensive and unpayable in some low-income countries. The new minimally invasive techniques have led to an increased use of these agents, especially flowable agents, such as gelatin-thrombin matrix, which can be applied in deep and difficult to reach locations, and fit to tissue spaces with minimal effort and without causing important side effects.[3,4]

We present a technique for creating a low-cost, highly effective, and practical flowable HA that can be used in open and endoscopic/minimally invasive procedures.

METHODS

The preparation of the HA was done in the operating room, at the beginning of the surgical procedure by the assistant surgeon (senior resident) or scrub nurse.

The materials needed to produce 10 mL of our HA are shown in Figure 1.

The first step was to scrape the gelatin foam (Spongostan, Ethicon, Johnson and Johnson, Somerville, New Jersey, USA; Gelfoam, Pfizer, New York, New York, USA; and Surgispon, Aegis Lifesciences, Ahmedabad, Gujarat, India, among others) with the scalpel blade until a thin layer was made. Afterward, we cut it into very small pieces to put the whole pieces inside one of the syringe barrels without the plunger (Figure 2).

The second step was to connect the plunger to the syringe and push halfway. Then it was connected with the 3-way stopcock and the other syringe filled with saline solution (thrombin could be added if available). The tap was then turned to close the third way. We then started pumping back and forth from one syringe to

Key words
- Cost-effective
- Hemostasis
- Hemostatic agent
- Self-made
- Surgical technique

Abbreviations and Acronyms
HA: Hemostatic agent

From the [1]Department of Neurosurgery, National Medical Center 20 of November, ISSSTE, Mexico City; [2]Head and Neck Department, Neuroscience Unit, National Cancer Institute, Mexico City; and [3]Department of Neurology and Neurosurgery, South Central High Specialty Hospital, PEMEX, Mexico City, Mexico

To whom correspondence should be addressed: Juan Leonardo Serrato-Avila, M.D. [E-mail: jls_avila@hotmail.com]

Citation: World Neurosurg. (2019) 122:224-228. https://doi.org/10.1016/j.wneu.2018.10.224

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

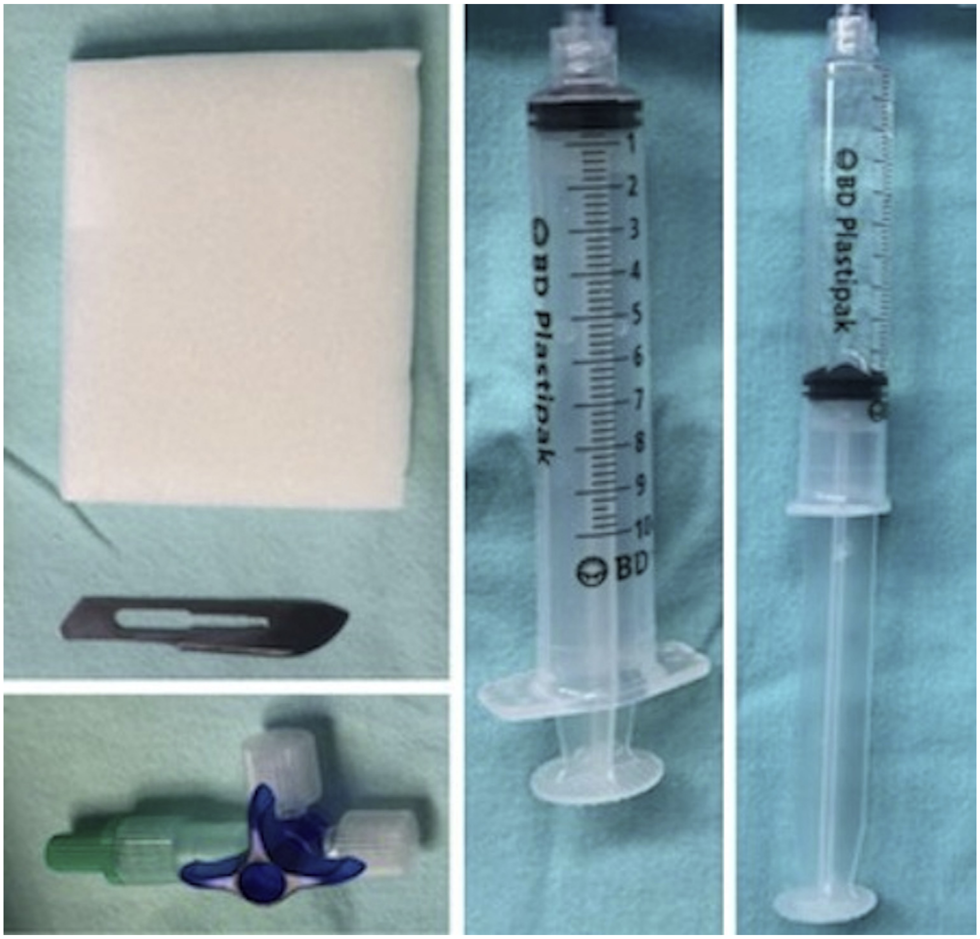

Figure 1. Photographs showing the materials needed for our hemostatic agent preparation: two 10-mL syringes, one 3-way stopcock, one piece of 7 × 5 × 1 cm gelatin foam, one scalpel blade number 20, and 10 mL of sodium chloride isotonic solution (0.9%).

the other for 3 minutes until the desired consistency was obtained.

The third step was to empty all the mixture into one of the syringes and disconnect it from the system. Finally, for open approaches we connected the widest intravascular catheter cap available (usually 14 G × 50 mm), and for endoscopic approaches we used a Frazier aspiration cannula, occluding the pressure regulation hole with bone wax, or just with the thumb, while homogeneously spreading the mixture in the bleeding site. To take out the residual mix of the cannula, we pumped one time with the syringe filled with air.

After the application, we made some pressure with the suction tube on a dry cotton patty to help product adhesion.

This technique was applied in 3 different tertiary referral centers in the same country, in a nonconsecutive way. The use of our HA instead of other commercial HAs was chosen according to the existing resources in the hospital at the time of the surgery, between 2017 and 2018. We used the product in a total of 230 procedures, including different types of pathologies, such as skull base, oncology, vascular, and trauma, either for endoscopic or open approaches (Figure 3). The patients in whom another hemostatic technique in the bleeding site was used were excluded, to make sure that our technique was the cause of hemostasis. The total time to prepare and mix the HA was measured. In term of costs, we compared the prices in our environment of the available gelatin-thrombin matrix FLOSEAL (Baxter International, Inc., Deerfield, Illinois, USA) and SURGIFLO (Ethicon, Johnson and Johnson, Somerville, New Jersey, USA) with our HA, including the adjuncts needed to prepare it.

RESULTS

Our hemostatic matrix had the same effectiveness in all procedures regardless of the pathology or approach, but only for venous or low-flow bleeding. In high-flow arterial bleeding, the HA was ineffective in achieving hemostasis because of very high pressure. In these cases, we used the suction device to isolate the bleeding site. After the hole in the artery was seen, the bipolar

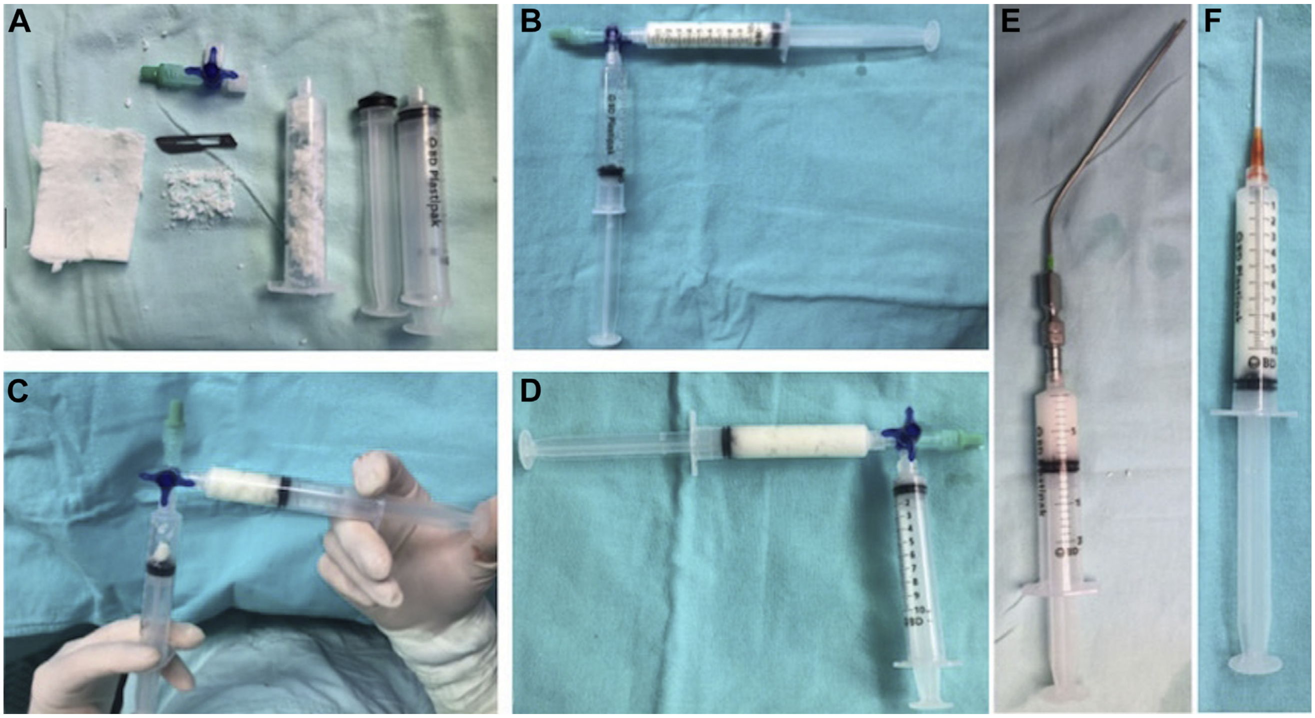

Figure 2. Intraoperative step-by-step preparation of our hemostatic agent. (**A**) The scraped gelatin foam is placed in the syringe barrel. (**B**) The loaded syringes are connected to the 3-way stopcock. (**C**) The mixture is being pumped from one syringe to the other. (**D**) The desired consistency is obtained and is ready to use. (**E**) The syringe is connected to a Frazier cannula for endoscopic use. (**F**) An intravascular catheter cap is connected to the syringe for open cranial surgery use.

electrocautery was gently applied once in the side wall of the affected vessel.

The mean time to prepare and mix our HA was 4 minutes, with a range of 4–5 minutes. On average, we achieved hemostasis within 1–2 minutes of application. The hemostatic effect was the same regardless of the time lapse from preparation to application. The cost of our product was 16 and 28 times less that the traditional available gelatin-thrombin matrix (SURGIFLO and FLOSEAL, respectively); therefore, we had costs savings of over 90% (**Tables 1** and **2**).

In terms of adverse effects, we did not find any.

DISCUSSION

Nowadays, the huge advances in minimally invasive techniques used to treat complex neurosurgical pathologies has led to the development of more effective HAs to perform these procedures in a safer way. These products are very expensive, especially for low-income countries with cost restrictions. Therefore, we developed our own technique to be able to operate on such complex pathologies in a safe manner without the cost limitation. We found savings of 30% more than Alonso et al.,[5] who compared a similar self-made HA for spine surgery with FLOSEAL. To our knowledge, this is the first report of a self-made flowable HA for cranial use that compares costs and provides a reachable option for hospitals with financial restrictions.

There are 2 previous studies in patients undergoing spine surgery which compared FLOSEAL and SURGIFLO. The studies show that patients who received FLOSEAL required fewer blood

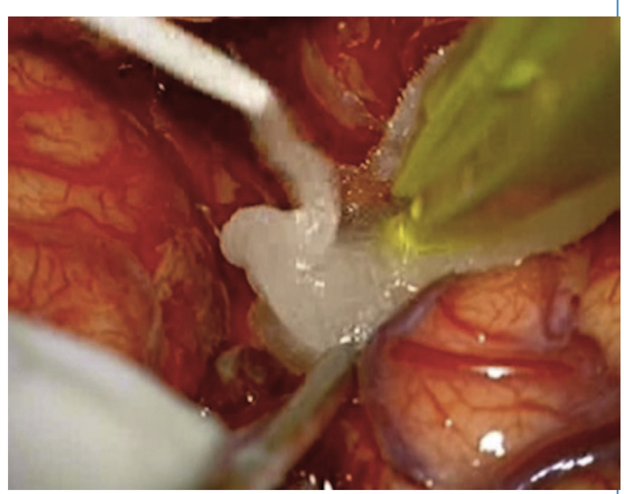

Figure 3. Illustrative case: intraoperative photograph showing the application of our hemostatic agent in an insular arteriovenous malformation resection cavity.

Table 1. Costs by Components of Our Self-Made Hemostatic Agent

Components	Cost of Self-Made Hemostatic Agent
Two 10-mL syringe	0.64
One 3-way stopcock	0.82
One piece of gelatin foam	19.29
One scalpel blade	0.09
10 mL of sodium chloride isotonic solution	0.08
One plastic cannula of intravascular catheter	0.52
Total cost	21.47

The prices are as available in Mexico City, Mexico, converted to U.S. dollars.

Table 2. Cost Comparison of Our Self-Made Hemostatic Agent with 2 Available Gelatin-Thrombin Matrix Hemostats

Cost of Available Prepackaged SURGIFLO, 8 cm^3-Unit	Cost of Available Prepackaged FLOSEAL, 5-cm^3 Unit	Cost of Self-Made Hemostatic Agent, 10-cm^3 Unit
359.73	616.63	21.47

The prices are as available in Mexico City, Mexico, converted to U.S. dollars.

transfusions and used less operating room time, resulting in important annual savings for the hospital, in contrast with the patients that received SURGIFLO.[6,7] Likewise, there is a series of 31 patients with primary intracranial hematomas that were treated by minimal craniotomy. After evacuation of the hematoma, FLOSEAL was injected in the surgical cavity, achieving good results, with only 1 patient reoperated.[8]

We found our HA to be most effective in low-flow and venous bleeding, useful in proximity of neurovascular structures that have to be preserved, and effective in maintaining visualization on the working field, in agreement with Kassam et al.[9]

On average, it takes 2 minutes longer to prepare our mixture in comparison with other reports preparing available gelatin-thrombin matrix.[5,10] The time in which we achieved complete hemostasis was similar to other HAs, including FLOSEAL, in a comparison made in a rat model.[10]

We have not performed a randomized controlled trial with our HA in comparison with currently available HAs because we do not pretend to demonstrate superiority. We just aim to offer a cost-effective alternative when high-cost products are not available.

Although we observed excellent results with our product, to determine exactly how much cost savings we gain from the procedure, more studies are needed to compare other parameters, such as operative case length, need for transfusion, and total operative room costs, between our HA and other available HAs.

In an experimental laboratory study by Katsumori and Kasahara,[11] it was found that cutting GELFOAM (Pfizer, New York, New York, USA) produces lower rates of smaller and larger particles, compared with pumping it. Therefore, we selected both techniques to achieve smaller and more uniform particle sizes. We did not used thrombin in our mixture because of its high cost and limited availability in our country; however, if available, it can be added.

There are 2 previous case reports of anaphylaxis reactions in pediatric patients with flowable HAs.[12,13] In our opinion, these reactions could be more likely caused by the thrombin rather than the gelatin. Although our mixture lowers anaphylaxis risk, it does exist in approximately 0.34%; therefore, we need to make sure the patient has no allergies to this product.[14]

CONCLUSIONS

The accurate selection of an HA in neurosurgery is a keystone because it can prevent irreversible deficits and even death. Here, we presented a simple, reliable, and cost-effective flowable HA that was made with worldwide-available gelatin foam, scraped and mixed with saline solution in 2 syringes connected by a 3-way stopcock. This HA represents an alternative for low-income countries to achieve hemostasis in open and endoscopic cranial surgery. Further studies with larger series, and comparison of this agent among other hemostats, are required for providing appropriate evidence.

REFERENCES

1. Stokes ME, Ye X, Shah M, Mercaldi K, Reynolds MW, Rupnow MF, et al. Impact of bleeding-related complications and/or blood product transfusions on hospital costs in inpatient surgical patients. *BMC Health Serv Res*. 2011;11:1-13.

2. Fiss I, Danne M, Stendel R. Use of gelatin-thrombin matrix hemostatic sealant in cranial neurosurgery. *Neurol Med Chir (Tokyo)*. 2007;47:462-467.

3. Ellegala DB, Maartens NF, Laws ER. Use of FloSeal hemostatic sealant in transsphenoidal pituitary surgery: technical note. *Neurosurgery*. 2002;51:2000-2003 [discussion: 515-516].

4. Cappabianca P, Esposito F, Esposito I, Cavallo LM, Leone CA. Use of a thrombin-gelatin haemostatic matrix in endoscopic endonasal extended approaches: technical note. *Acta Neurochir (Wien)*. 2009;151:69-76.

5. Alonso F, Rustagi T, Iwanaga J, Fisahn C, Oskouian R, Tubbs RS, et al. Self-made, cost-reducing hemostatic agent for use in spine surgery. *World Neurosurg*. 2017;108:90-93.

6. Makhija D, Rock M, Ikeme S, Kuntze E, Epstein JD, Nicholson G, et al. Cost-consequence analysis of two different active flowable hemostatic matrices in spine surgery patients. *J Med Econ*. 2017;20:606-613.

7. Price JS, Tackett S, Patel V. Observational evaluation of outcomes and resource utilization from hemostatic matrices in spine surgery. *J Med Econ*. 2015;18:777-786.

8. Gazzeri R, Galarza M, Neroni M, Alfieri A, Esposito S. Minimal craniotomy and matrix hemostatic sealant for the treatment of spontaneous supratentorial intracerebral hemorrhage. *J Neurosurg*. 2009;110:939-942.

9. Kassam A, Snyderman CH, Carrau RL, Gardner P, Mintz A. Endoneurosurgical hemostasis

techniques: lessons learned from 400 cases. *Neurosurg Focus*. 2005;19:E7.

10. Ereth MH, Schaff M, Ericson EF, Wetjen NM, Nuttall GA, Oliver WC. Comparative safety and efficacy of topical hemostatic agents in a rat neurosurgical model. *Neurosurgery*. 2008;63(4 suppl):369-372.

11. Katsumori T, Kasahara T. The size of gelatin sponge particles: differences with preparation method. *Cardiovasc Intervent Radiol*. 2006;29:1077-1083.

12. Agarwal NS, Spalding C, Nassef M. Life-threatening intraoperative anaphylaxis to gelatin in Floseal during pediatric spinal surgery. *J Allergy Clin Immunol Pract*. 2015;3:110-111.

13. Spencer HT, Hsu JT, McDonald DR, Karlin LI. Intraoperative anaphylaxis to gelatin in topical hemostatic agents during anterior spinal fusion: a case report. *Spine J*. 2012;12:e1-e6.

14. Hepner DL, Castells MC. Anaphylaxis during the perioperative period. *Anesth Analg*. 2003;97:1381-1395.

Conflict of interest statement: The authors declare that the article content was composed in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Received 19 September 2018; accepted 29 October 2018

Citation: World Neurosurg. (2019) 122:224-228.
https://doi.org/10.1016/j.wneu.2018.10.224

*Journal homepage: **www.WORLDNEUROSURGERY.org***

*Available online: **www.sciencedirect.com***