

1 **Suturing of the Arachnoid Membrane for Reconstruction of the Cisterna Magna:**
2 **Technical Considerations**

3
4 Umit Eroglu, MD,¹ (orcid 0000-0001-8623-071X), Murat Büyüktepe, MD,¹ Murat Zaimoğlu,
5 MD,¹ Gokmen Kahilogullari, MD,¹ Hasan Caglar Ugur, MD,¹ Mustafa Ağahan Ünlü, MD,¹
6 Aaron Cohen-Gadol, MD, MSc, MBA^{2,3} (orcid 0000-0002-4946-1524)

7
8 ¹Department of Neurosurgery, Ankara University, School of Medicine, Ankara, Turkey; ²*The*
9 *Neurosurgical Atlas*, Carmel, Indiana; and ³Department of Neurological Surgery, Indiana
10 University, Indianapolis, Indiana

11
12 **Correspondence:** Aaron Cohen-Gadol, MD, MSc, MBA, Indiana University, Department of
13 Neurological Surgery, 355 W 16th Street, Suite 5100, Indianapolis, IN 46202;
14 cohen@nsatlas.com.

15
16 **Short Title:** Suturing of the Arachnoid Membrane

17
18 **Key words:** arachnoid membrane; cerebrospinal fluid leak; cisterna magna; dural closure;
19 running-suture technique

20
21 This manuscript (i) is a unique submission, (ii) has not been submitted and is not being
22 considered for publication by any other source in any medium, and (iii) has not been published,
23 in part or in full, in any form.

24
25 **Conflict of Interest:** The authors have no personal, financial, or institutional interest in any of
26 the drugs, materials, or devices described in this article.

27
28 **Disclosure of Funding:** None.

29
30 **Abbreviation:** CSF, cerebrospinal fluid

This is the author's manuscript of the article published in final edited form as:

Eroglu, U., Büyüktepe, M., Zaimoğlu, M., Kahilogullari, G., Ugur, H. C., Ünlü, M. A., & Cohen-Gadol, A. (2021). Suturing of the Arachnoid Membrane for Reconstruction of the Cisterna Magna: Technical Considerations. *World Neurosurgery*, 154, e724-e728. <https://doi.org/10.1016/j.wneu.2021.07.129>

- 1 **Suturing of the Arachnoid Membrane for Reconstruction of the Cisterna Magna:**
- 2 **Technical Considerations**

3 **ABSTRACT**

4 **Background:** Postoperative cerebrospinal fluid (CSF) fistula following cranial or spinal
5 surgery is associated with increased morbidity and mortality. To prevent CSF fistulas, various
6 techniques have been described.

7

8 **Objective:** To describe the arachnoid membrane continuous-running-suture technique in
9 cisterna magna reconstruction for preventing postoperative CSF leakage.

10

11 **Methods:** After craniotomy and dural opening, the incision of the arachnoid of the cisterna
12 magna was performed using a diamond blade. To prevent the arachnoid from drying out and
13 shrinking during surgery, it was periodically irrigated with warm saline solution. Posterior
14 fossa surgery was performed. While closing the membranes, the arachnoid membrane was
15 closed with the running-suture technique. After the first surgical knot was made in the cranial
16 end of the arachnoid opening, continuous suturing with a 2-mm distance between the stitches
17 was performed without stretching them. After every 3 stitches, the free end of the thread was
18 pulled gently along the suturing axis, and the edges of the arachnoid were closed. After the
19 arachnoid edges were approximated, the surgical knot was tied. Watertight closure was
20 checked by performing the valsalva maneuver at the end of the surgery.

21

22 **Results:** No CSF leakages were observed after surgery.

23

24 **Conclusion:** Arachnoid membrane suturing seems to be safe and effective in preventing
25 postoperative CSF leakage and CSF-related complications. Using continuous running suturing
26 alone, without any sealant, might be effective in cases with untraumatized arachnoid
27 membrane.

28 **BACKGROUND AND AIM**

29 Postoperative cerebrospinal fluid (CSF) fistula after cranial or spinal surgery is associated
30 with increased morbidity and mortality. The incidence of postoperative CSF leakage has been
31 reported as high as 32% after nontraumatic posterior fossa surgery.¹ Postoperative CSF fistula
32 can be complicated by meningitis, encephalitis, low-pressure headaches, chronic subdural
33 hematomas and effusions, pseudomeningocele, arachnoiditis, dural-cutaneous fistula, pain,
34 and pneumocephalus.^{2,3} The development of complications may depend on the location and
35 size of craniotomy, as well as patient-related factors such as age and systemic disease. These
36 complications often lead to prolonged hospitalization, reoperation, and increased mortality
37 and morbidity rates.² Various techniques to prevent CSF-related postoperative complications
38 have been described. First, tight and reliable closure of the dura mater and fascia should be
39 achieved.³ Also, compressive bandaging, direct aspiration of subcutaneous CSF or diversion
40 of ventricular CSF,⁴ skin sutures, various tissue adhesives,^{1,5} dural grafts,⁶ and surgical
41 closure of the fistula are some of the interventions that can prevent and treat CSF leakage
42 outside the closed dural incision.⁷

43

44 In this technical note, we report a case series in which continuous running suturing of the
45 arachnoid membrane was included in cisterna magna reconstruction to prevent postoperative
46 CSF-related complications.

47

48

49 **SURGICAL TECHNIQUE**

50 All surgeries were performed by the same surgeons. This case series included 11 patients
51 without any history of previous surgery, and none of them had received radiotherapy
52 treatment. All of the patients underwent surgery via a midline suboccipital approach.

53

54 After the induction of general anesthesia, each patient was positioned in the prone position
55 with head flexed using a three-point rigid cranial fixation system. After median skin incision,
56 a suboccipital craniotomy or craniectomy was performed over the cerebellar hemispheres to
57 expose the foramen magnum. The edges of the foramen were expanded by using a rongeur.
58 While performing the craniotomy, dural injury was avoided, and no CSF leakage was
59 observed. The posterior fossa dura was opened in the midline in a Y-shaped fashion over the
60 cerebellar hemispheres bilaterally with a no. 15 blade. While opening the dura, small
61 hemorrhages were managed with saline irrigation or pressure but not bipolar cautery. Care
62 was taken also to avoid incidental cisterna magna arachnoid tearing.

63

64 After the dural opening was completed, the arachnoid of the cisterna magna was incised with
65 a diamond blade. During the arachnoid incision, care was taken to perform a continuous,
66 linear incision with sharp edges, not serrated. The arachnoid was irrigated copiously with
67 warm saline solution while the incision was performed. As an important note, the edges of the
68 arachnoid membrane were not clipped to the underlying dural flap bilaterally. In this way, the
69 corruption or shrinkage of the membrane was prevented. To prevent the arachnoid from
70 drying out and shrinking during surgery, it was irrigated periodically with warm saline
71 solution.

72

73 Posterior fossa surgery was performed, and meticulous hemostasis was achieved. After
74 irrigation of the arachnoid, the edges were gently moved to the midline with fine forceps. The
75 arachnoid membrane was sutured with 10.0 Prolene, beginning from the cranial end of the
76 incision (Figure 1). The running-suture technique was performed. Accordingly, after the first
77 surgical knot was made in the cranial end of the arachnoid opening, continuous suturing with

78 a 2-mm distance between the stitches was performed without stretching them. After every 3
79 stitches, the free end of the thread was pulled gently along the suturing axis, and the edges of
80 the arachnoid were closed (pulling the thread after every 3 stitches instead of after every stitch
81 decreases traumatic injury to the arachnoid edges). During the pulling maneuver, the
82 arachnoid was irrigated with warm saline solution. After the arachnoid edges were
83 approximated, the surgical knot was tied (Video 1). Watertight closure of the cisterna magna
84 arachnoid membrane was checked by the Valsalva maneuver, and no CSF leakage was
85 observed (Figures 2 and 3).

86

87 The dura was closed using synthetic or galeal graft tissue. Other anatomical layers were
88 closed accordingly. The bone flap was placed and fixed with sutures, and the wound was
89 closed in a conventional manner.

90

91 All procedures were in accordance with the ethical standards of the institutional and/or
92 national research committee and with the 1964 Helsinki declaration and its later amendments
93 or comparable ethical standards.

94

95 **RESULTS**

96 Eleven patients (6 male, 5 female) with a mean age of 37.58 ± 20.34 years were included in
97 the study. The patients presented mostly with headache, dizziness, and vomiting. Four
98 patients had hydrocephaly at baseline. All patients underwent posterior fossa surgery via a
99 midline suboccipital approach. Arachnoid closure with the continuous-running-suture
100 technique was effective in preventing postoperative incisional CSF leakage and CSF fistula in
101 all the patients. Among 4 patients who had preoperative hydrocephalus, 2 patients underwent
102 ventriculoperitoneal shunt surgery. Seven patients had neither preoperative nor postoperative

103 hydrocephalus. Postoperative histopathological investigations revealed mostly glial tumors
104 (Table 1). No patient suffered from any related complications at the 2- and 6-month
105 postoperative follow-ups.

106

107 **DISCUSSION**

108 In the past literature, there are few data available regarding the safety and efficacy of
109 arachnoid suturing in the prevention of CSF leakage after cranial or spinal tumor surgery are
110 available. Previously, Raimondi⁸ recommended close-interrupted or continuous suturing of
111 the arachnoid membrane after spinal surgery, especially after that performed for
112 syringomyelia. More recently, Kim et al.⁹ evaluated the presence of postoperative subdural
113 CSF collection in 88 patients who underwent extracranial–intracranial bypass surgery with (n
114 = 32) or without (n = 51) arachnoid membrane suturing. The authors reported that arachnoid
115 suturing significantly decreased the rate of CSF leakage into the subdural space. In addition,
116 Pitshkelaury et al.³ investigated pseudomeningocele and incisional CSF leakage rates after
117 cisterna magna surgery with arachnoid membrane suturing followed by sealing with fibrin
118 adhesive material. The study enrolled 70 patients, 32 of whom were in the control group.
119 Postoperative pseudomeningocele and incisional CSF leakage were reported to be seen in
120 34.4% and 6.3% cases, respectively, in the control group. However, these complications were
121 seen in only 5.2% of the cases in the study group in which the arachnoid membrane was
122 sutured. Accordingly, this technique was found to create an additional barrier for CSF leakage
123 and decreased the risk of postoperative CSF-related complications. The authors performed
124 continuous uninterrupted suturing with 7-0 suture. After completing all sutures without
125 stretching the arachnoid membrane, the free end of the thread was pulled once along the
126 suture to close the incised edges of arachnoid.³ However, according to our clinical
127 experiences, we believe that 6-0 or 7-0 sutures might injure the arachnoid membrane. Also,

128 pulling the thread only at the end of suturing might cause arachnoid stretching and microtears.
129 Therefore, in our cases, we used 10-0 suture material and the running-suturing technique.

130

131 In our study, while opening the dura and separating and peeling away the dura from the
132 arachnoid, we paid attention to avoid inadvertent arachnoid injury. Suturing of the arachnoid
133 membrane is simple for experienced neurosurgeons who are skilled in microanastomosis.
134 However, a key to success with this type of closure is not only the suturing of the arachnoid
135 but also the cutting. We performed a single, continuous, and sharp incision of the arachnoid
136 membrane. At the end of surgery, we performed arachnoid suturing not only continuously but
137 also with the running-suture technique and the membrane copiously irrigated with warm
138 saline solution. These factors might minimize intraoperative trauma to the arachnoid
139 membrane so that watertight closure and a stable barrier against CSF leakage could be
140 achieved without necessitating supportive fibrin-adhesive material sealing.

141

142 There are several limitations in our study. The study had a retrospective case-series design,
143 there was a limited number of patients, and no control group. Still, we believe that the
144 technique described in our study may provide additional information about the efficacy of
145 arachnoid suturing.

146

147 According to our study results, arachnoid membrane suturing seems to be safe and effective in
148 preventing postoperative CSF leakage and CSF-related complications. In addition, using the
149 continuous-running-suture technique alone, without any sealant, might be effective in patients
150 with untraumatized arachnoid membrane. Considering the high risk of postoperative CSF
151 leakage and related complications after posterior fossa surgery, we suggest that the

152 continuous-running-suture technique for closing the arachnoid membrane is worthy of
153 widespread use.

154

155 **ACKNOWLEDGEMENT**

156 The authors sincerely appreciate the support of the Stead Family Endowed Chair in creation
157 of this work.

158 **REFERENCES**

159

160 1. Kumar A, Maartens NF, Kaye AH. Evaluation of the use of BioGlue in neurosurgical
161 procedures. *J Clin Neurosci*. 2003;10(6):661-664.

162 2. Kinaci A, Algra A, Heuts S, O'Donnell D, van der Zwan A, van Doormaal T.
163 Effectiveness of dural sealants in prevention of cerebrospinal fluid leakage after
164 craniotomy: a systematic review. *World Neurosurg*. 2018;118:368-376.e1.

165 3. Pitskhelauri D, Kudieva E, Moshchev D, et al. Cisterna magna arachnoid membrane
166 suturing decreases incidence of pseudomeningocele formation and incisional CSF
167 leakage. *Acta Neurochir (Wien)*. 2018;160(5):1079-1087.

168 4. Culley DJ, Berger MS, Shaw D, Geyer R. An analysis of factors determining the need
169 for ventriculoperitoneal shunts after posterior fossa tumor surgery in children.
170 *Neurosurgery*. 1994;34(3):402-407; discussion 407-408.

171 5. Cosgrove GR, Delashaw JB, Grotenhuis JA, et al. Safety and efficacy of a novel
172 polyethylene glycol hydrogel sealant for watertight dural repair. *J Neurosurg*.
173 2007;106(1):52-58.

174 6. Knopp U, Christmann F, Reusche E, Sepehrnia A. A new collagen biomatrix of equine
175 origin versus a cadaveric dura graft for the repair of dural defects—a comparative
176 animal experimental study. *Acta Neurochir (Wien)*. 2005;147(8):877-887.

177 7. Fang Z, Tian R, Jia Y-T, Xu T-T, Liu Y. Treatment of cerebrospinal fluid leak after
178 spine surgery. *Chin J Traumatol*. 2017;20(2):81-83.

179 8. Raimondi AJ. *Pediatric Neurosurgery: Theoretical Principles—Art of Surgical
180 Techniques*. New York, NY: Springer; 1998:138-139.

181 9. Kim GW, Joo SP, Kim TS, et al. Arachnoid membrane suturing for prevention of
182 subdural fluid collection in extracranial-intracranial bypass surgery. *J Cerebrovasc*

184 Figure 1. The arachnoid membrane is closed with 10.0 Prolene suture using the continuous-
185 running-suture technique.

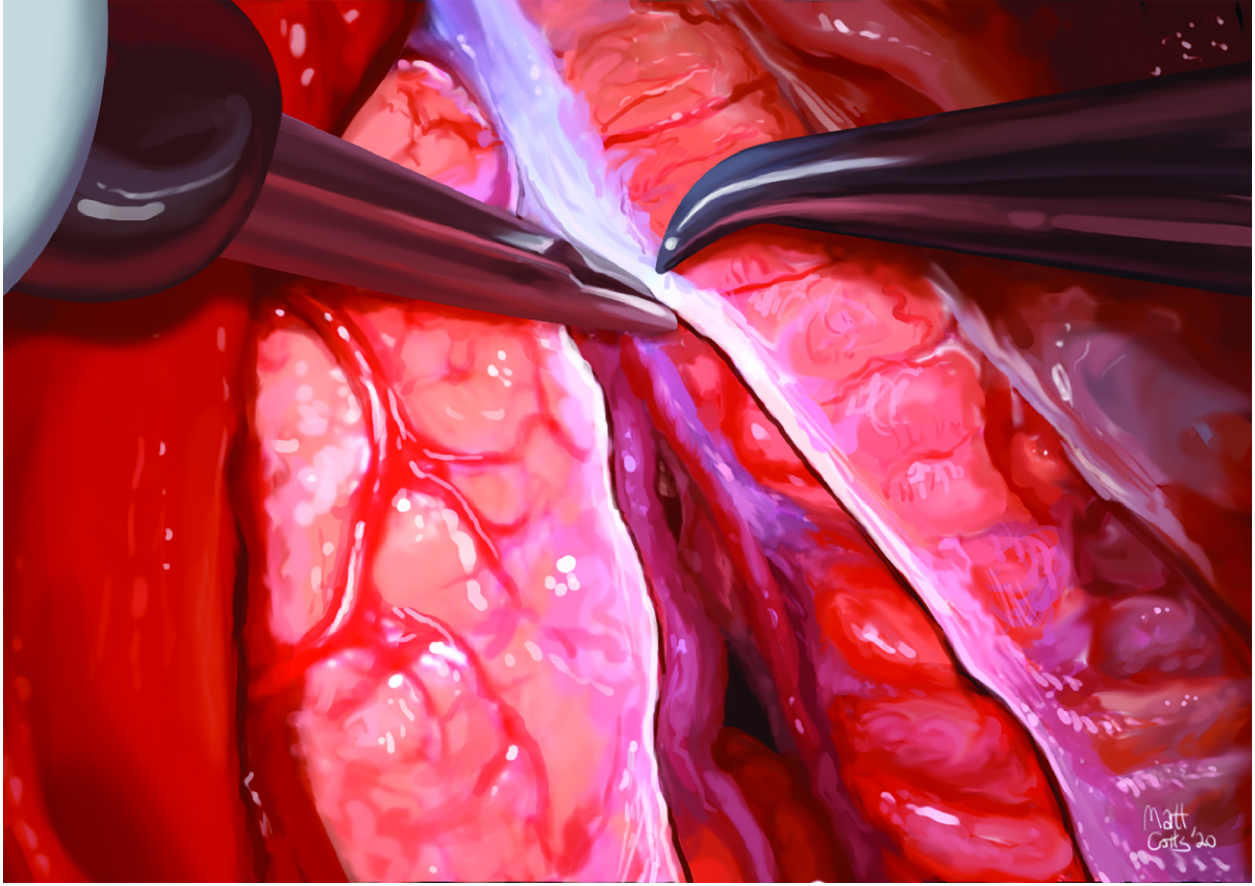
186 Figure 2. Illustration of the watertight closure of the arachnoid membrane at the end of
187 surgery.
188

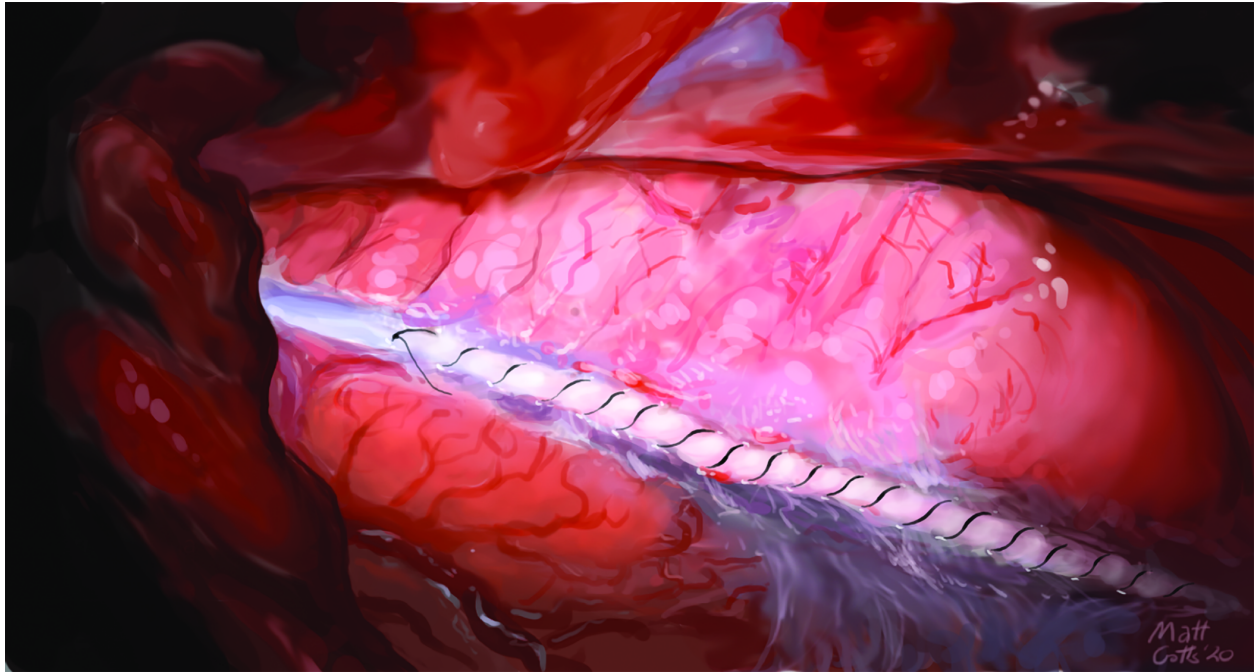
189 Figure 3. Intraoperative images of watertight closure of the arachnoid membrane during (A)
190 and at the end of (B) suturing.

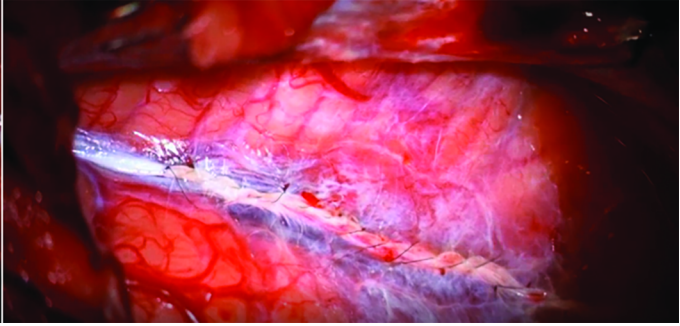
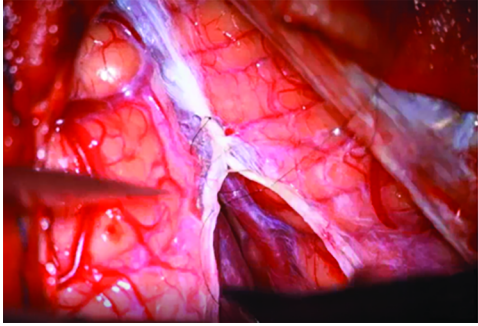
191 Video 1. Arachnoid membrane suturing with the continuous-running-suture technique.

Table 1. Patient demographic and clinical data

Patient Characteristic	Value
Sex (no.)	
Male	6
Female	5
Age (mean \pm SD) (yrs)	37.58 \pm 20.34
Symptoms (no. [%])	
Headache	9 (81.8)
Dizziness	5 (45.5)
Vomiting	4 (36.4)
Nausea	3 (27.3)
Ataxia	3 (27.3)
Preoperative hydrocephaly (no. [%])	4 (36.4)
Preoperative radiotherapy (no. [%])	0 (0.0)
Histopathological diagnosis (no. [%])	
Metastases	3 (27.3)
Lung cancer	2 (18.2)
Breast cancer	1 (9.1)
Glial tumors	6 (54.5)
Astrocytoma	2 (18.2)
Medulloblastoma	2 (18.2)
Ependymoma	2 (18.2)
Other	
Hemangioblastoma (no. [%])	2 (18.2)







**Suturing of the Arachnoid Membrane for Reconstruction of the Cisterna Magna:
Technical Considerations**

Abbreviations: none