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Value of achieving a watertight dural closure, and the use of dural sealants after supratentorial cranial surgery

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Abstract

Dural closure at the end of cranial surgery is considered an extremely important step to maintain anatomical continuity, separate the intradural space with the extra-dural one, and to prevent possible complications related to cerebrospinal fluid leak. Wherein its usefulness in posterior fossa craniotomy is established, many surgeons do not perform it routinely in supratentorial craniotomies, citing unnecessary delay and lack of evidence supporting it. Herein, we have reviewed the data to find evidence in support of watertight suture based dural closures compared to other dural closure techniques, in supratentorial craniotomies.

Introduction

Cerebrospinal fluid (CSF) leaks are common post-operative complications in cranial surgeries, occurring from 4% to 32% in most neurosurgical procedures.[1,2] They can further lead to the formation of CSF fistulas, abscesses and pseudo-meningoceles (PM).[3] To avoid these, generations of neurosurgeons have religiously followed one of the final steps in cranial surgery: the meticulous closure of dura to perfectly re-establish anatomical layers. While there is little in terms of evidence to support its importance, especially in supratentorial craniotomies, the tradition stems from 1908, when Harvey Cushing stated that "an accurate approximation of the dura in its two layers should be painstakingly done".[4,5]

In many cases, a primary watertight dural closure is not possible and numerous materials have been used for a secondary watertight closure. These include autologous grafts such as the pericranium and fascia, as well allografts, xenografts and dural sealants.[4,5] In other cases, such as the extracranial bypass surgeries, where the dura is completely excised over the cortical area where anastomosis is performed, surgeons have experienced no significant post-operative complications.[4]

Herein, we have reviewed the practice of watertight dural closures (WTDC) to re-evaluate its necessity in supratentorial craniotomies for tumours, in terms of efficacy in preventing CSF related complications, and contribution to surgery time and hospital costs.

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Review of Literature

Cho et al., in a prospective study compared the practice of WTDC with non-WTDC, with and without the use of dural grafts. They concluded that for supratentorial craniotomies, WTDC was comparable in outcomes to non-WTDC, with similar CSF leakage rates in both groups.[6] Similar results were also seen in infratentorial craniotomies with small dural incisions, with no influence of dural grafts on the leak.[6] In contrast, Grotenhuis et al., in a single center retrospective study, evaluated 412 neurosurgical patients for cost of managing and preventing post-operative CSF leak. They found an overall leak rate of 10.7%, which was associated with high additional costs, averaging to $1,508 per patient, and reported a saving of $550 per patient with the prophylactic use of a Duraseal, as a dural sealant (saving $2,26,600 in their series). However, a significantly lower leak rate was reported with supratentorial procedures as compared to infratentorial procedures, and this subgroup was not independently evaluated.[1]

Barth et al., conducted a randomized controlled trial (RCT) to study complication rates and cost associated with the technique of dural closure in patients undergoing supratentorial craniotomies. A total of 150 patients were included and divided into 3 groups, with patients in group A, B and C undergoing primary watertight dural closures, secondary watertight dural closures and adaptive dural closures respectively. Complications of CSF leak in the form of subcutaneous wound collections, impaired wound healing and infections were found in 7, 6 and 12 patients in groups A, B and C respectively, with no significance in this difference. However, the time for dural closure was significantly reduced in Group C as compared to Group A and B (p=0.001), contributing to the cost. Mean cost, based on time and additional material required in Group A (US $436) or Group B (US $681) were significantly greater compared with adaptive dural closure in Group C (US $213) (p <0.05), which led them to conclude that adaptive

Table-: Complications in WTDC compared to non-WTDC.

Study	Study design	Outcome	WTDCx	Non-WTDCx	p-value
Cho et al. 2000[6]	Prospective cohort	CSF leak	4 (25)	5 (49)	> 0.05
Barth et al. 2008[4]	Randomized controlled trial	Overall complications	13 (87)	12 (50)	> 0.05
Hutter et al. 2014[7]	Randomized controlled trial	CSF leak	11 (113)	20 (116)	0.108
Abouelmaatey et al. 2016[8]	Prospective cohort	Overall complications	7 (47)	6 (25)	> 0.05
Vieira et al. 2017[9]	Randomized controlled trial	Overall complications	5 (28)	4 (27)	1.0
Kinaci et al. 2018[2]	Systemic review	CSF leak	88 (1078)	104 (1243)	0.51
Roth et al. 2018[5]	Retrospective cohort	Overall complications	1 (18)	35 (145)	> 0.05
Alwadei et al. 2019[3]	Retrospective cohort	CSF leak	2 (114)	6 (102)	0.15

dural closures are safe and cost-effective alternatives to watertight dural closures in supratentorial craniotomies.[4]

Hutter et al., in an RCT involving 229 patients undergoing elective craniotomy, compared standard running dural suture alone, with the addition of a dural sealant TachoSil, on top of the suture. Outcomes included CSF leakage, infection, surgical revision and length of hospital stay. Apart from a questionable reduction in frequency of post-operative sub-galeal swelling and length of hospital stay, they did not find any benefit of using the sealant.[7] Abouelmatey et al., through a prospective cohort study of 72 patients undergoing supratentorial craniotomies, compared post-operative complications after three types of dural closures. Patients were divided into groups A, B and C containing patients undergoing primary WTDC, secondary WTDC and adaptive non-WTDC respectively. Post-operative complications such as subcutaneous CSF collections, delayed wound healing and meningitis, occurred in 3 cases of Group A, 4 cases of group B and 6 cases of group C. All complications were, however, not significant between the three groups, leading to the conclusion that adaptive non-WTDC was a better and faster alternative to the other dural closure techniques in supratentorial craniotomies.[8]

Vieira et al., in another RCT compared 58 patients in two groups for the incidence of surgical complications such as wound infection, CSF leak, brain abscesses, surgical time and hospital costs. The control group underwent watertight duroplasty, whereas the test group underwent rapid closure DC, without watertight duroplasty. They reported[9] surgical complications, 5 in the control group and 4 in the test group, with no significant differences between the groups. However, a significant difference of 31 minutes was noted in mean surgical time (control group 132 minutes, test group101 minutes). This also led to a mean reduction of 23.4% in the total cost per procedure in the test group. The authors thus described rapid closure DC without watertight duroplasty to be safe, without being associated with a higher rate of surgical complications.[9] Roth et al., published their series of 163 paediatric patients (3 months to 18.5 years) with non-WTDC. Main surgical indication was tumours (120 patients), and 122 procedures were supratentorial. The authors performed non-WTDC in 89% of the cases, with a dural substitute in 156 cases. They reported 1 CSF leak (0.6%), 8.4% clinical PM at 3 months, and 3% clinically obvious PM at 1 year post-operatively, with 15 patients undergoing CSF diversion procedures. However, the only factor significantly associated with the development of a PM or CSF diversion procedures was the infratentorial location of the lesion. The authors thus recognized non-WTDC as a quick and safe procedure with a short incision owing to the reduced need to harvest additional tissue.[5]

Kinaci et al., in a systematic review evaluated the efficacy of dural sealants in preventing CSF leakage and its related complications of PM formation and surgical site infections.2 Out of the 20 included articles, 3 were RCT, with 10 comparing sealants with no sealant use. In a total of 3682 reported procedures, the number of CSF leakages in general did not differ between the sealant group (8.2%) and control group (8.4%), and no difference was found in the PM formation (risk ratio RR=1.50). Surgical site infection was reported to be less in the sealant group however, its significance was not established. Thus, with no reductions noted in CSF leaks and PM formation, the application of dural sealants after craniotomies was not found useful by the authors.[2] Alwadei et al., published a series of 216 patients undergoing supratentorial craniotomy, comparing outcomes of suturing the dura and no dural closure. Among other things, they also looked for post-craniotomy headaches. With 112 patients in the open group, and 114 in the closed group, they experienced a greater incidence of infection and CSF leak in the open group (6 vs. 2 in the closed group), but without statistical

significance (p=0.15). However, significantly greater association of post-craniotomy headaches was shown in the closed group (p=0.001), leading to the authors establishing suturing of the dura as an unnecessary step in supratentorial craniotomies.[3]

Conclusion

The authors conclude that a watertight dural closure after supratentorial craniotomy, with or without sealants, does not significantly contribute to lowering complication rates with regards to CSF leakage, pseudo-meningocele formation or surgical infection. They do however, contribute to increasing patients' surgical times and hospital costs.

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