

Active Cerebrospinal Fluid Exchange vs External Ventricular Drainage in the Neurocritical Care Unit: An International, Retrospective Cohort Study

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Presented in part at Congress of Neurological Surgeons Annual Meeting in Washington, DC, September 9 to 13, 2023; Neurosurgical Society of the Virginias Annual Meeting in White Sulphur Springs, WV, January 25 to 27, 2024; International Neurotrauma Society Annual Meeting in Cambridge, UK, September 2 to 5, 2024.

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Received, October 03, 2024; **Accepted,** April 08, 2025; **Published Online,** June 23, 2025.

Neurosurgery 00:1–7, 2025

<https://doi.org/10.1227/neu.0000000000003587>

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BACKGROUND AND OBJECTIVES: Active cerebrospinal fluid exchange (ACE) through the dual-lumen IRRFlow catheter is a technique that has been used in the treatment of intraventricular hemorrhage and subarachnoid hemorrhage, ventriculitis, and others. Previous reports have consisted of small numbers of patients and focused on particular conditions. Our objective was to complete a multi-institutional retrospective cohort study to evaluate the safety and clinical outcomes of ACE therapy through the IRRFlow catheter.

METHODS: Multiple academic neurocritical care units from the United States and Europe contributed patients treated with either ACE or external ventricular drainage to a retrospective database. Complications including failure to drain, inadvertent removal, infection, cerebrospinal fluid leak, insertional hemorrhage, and early replacement were compared. Shunt dependence and modified Rankin score were also compared.

RESULTS: A total of 401 treated with external ventricular drainage and 118 treated with ACE were included. Diagnoses included were subarachnoid hemorrhage, intraventricular hemorrhage, and ventriculitis. ACE therapy showed fewer overall complications (odds ratio [OR] = 0.29, $P < .0001$), failures to drain (OR = 0.21, $P = .0004$), infections (OR = 0.2, $P < .0001$), cerebrospinal fluid leak (OR = 0.26, $P = .017$), and early replacements (OR = 0.4, $P = .036$). There was no difference in insertional hemorrhage or inadvertent removal. ACE therapy was associated with a lower rate of shunt dependence (OR = 0.28, $P < .0001$) and higher likelihood of discharge with a modified Rankin score of 0 to 2 (OR = 2.47, $P = .001$).

CONCLUSION: ACE therapy with the IRRFlow catheter is associated with fewer complications and improvement in some clinical outcomes. These results need to be confirmed with prospective and randomized trials.

KEY WORDS: External ventricular drainage, EVD, IRRFlow, Active CSF exchange

Many diseases that are cared for in the neurocritical care unit (NCCU) have high morbidity and mortality. Included among these are intraventricular hemorrhage

(IVH), bacterial ventriculitis, and subarachnoid hemorrhage (SAH).^{1,2} Mortality across these conditions can be as high as 30% to 80%.^{3,4} These diseases often present with symptomatic

ABBREVIATIONS: ACE, active cerebrospinal fluid exchange; EVD, external ventricular drain; IT, intrathecal; NCCU, neurocritical care unit; REDCap, Research Electronic Data Capture.

hydrocephalus that is traditionally treated with an external ventricular drain (EVD).

Although EVD placement is a lifesaving procedure, it has several limitations including a high rate of complications.^{5,6} Common complications include occlusion requiring either replacement or opening of the sterile system, infection, displacement, and failure to drain, among others. Continuous access to the cerebrospinal fluid (CSF) through EVD placement allows the use of intrathecal (IT) medications. This has been reported previously with variable results.⁷⁻¹⁰ Despite the benefits of IT therapies, the technical limitation of their delivery, primarily through EVD in the NCCU, has limited their widespread use. Examples of these limitations are the need to clamp the drain after delivery, poor distribution of medication throughout the CSF, and repeated violation of the sterility of the EVD circuit. Continuous irrigation and drainage of the ventricular system through a dual lumen catheter has been reported as a technique to avoid EVD complications and as a method to deliver IT medications more easily and reliably.

Several reports have demonstrated the technical feasibility of active cerebrospinal fluid exchange (ACE) as a therapy through a dual lumen catheter. They have reported good technical success and low complication rates.¹¹⁻²¹ Despite growing experience across many centers, direct comparison of the ACE techniques remains rare. One study attempted a randomized trial of ACE with standard therapy, but high rates of crossover and significant technical issues with the ACE technique reported prevent definitive conclusions from being drawn from this study.²²

Objective

The objective of this study was to compare complication rates of ACE therapy with standard EVD through a multi-institutional retrospective design focusing on IVH, SAH, and ventriculitis.

METHODS

This study was performed under the approval of the institutional review board. All procedures were completed after informed consent was obtained. Study data were collected and managed using Research Electronic Data Capture (REDCap) electronic data capture tools hosted at the corresponding author's institution. REDCap is a secure, web-based software platform designed to support data capture for research studies.^{23, 24} Before analysis, patient data were deidentified with the REDCap deidentification program. Data were gathered retrospectively from patient electronic medical records. Reporting of this study followed the STROBE checklist for cohort studies.²⁵

Four academic institutions from Europe and the United States contributed to the study. Patients undergoing treatment of IVH (with and without associated parenchymal hematoma, spontaneous SAH, or ventriculitis with EVD or ACE therapy) were included. ACE therapy was performed with the IRRARflow (IRRAS Inc.). EVD vs ACE therapy was decided at the discretion of the treating physician and was not guided by a prespecified protocol. The individual criteria for placing an IRRARflow were not tracked. The IRRARflow device has been described in the

literature previously, but briefly, consists of a dual lumen catheter inserted into the lateral ventricle. It can irrigate through one lumen, while draining through the other, with intermittent, automatic intracranial pressure monitoring. The outer diameter of the IRRARflow is 9.2F, whereas the EVD used had outer diameters of ~9F. Placement of the devices was performed in the standard fashion, with or without stereotactic guidance. Stereotactic guidance was at the discretion of the treating physician. Techniques used have been previously published¹⁷ and are similar to standard EVD placement techniques.

IT medications and orders for the ACE therapy followed previously reported protocols.¹⁷ Variables collected included patient age, sex, admission and discharge, modified Rankin score (MRS), Glasgow Coma Score (GCS), shunt dependence, and complications. Complications collected included insertional or removal hemorrhage, infection, CSF leak, drain occlusion, failure to drain, inadvertent removal, and early replacement. Other data included days of treatment and IT medication given.

Continuous variables are described with mean and SEs and compared with unpaired *t*-tests. Categorical variables are displayed as counts and percentages and were compared with χ^2 tests. Statistical comparisons were made using Microsoft Excel (Microsoft Inc). Significance was set at $P < .05$, with a modified Bonferroni correction to account for multiple comparisons. Ninety-five percent confidence intervals are provided for each comparison.

RESULTS

Demographic and treatment data for the cohort are displayed in Table 1. In total, 401 patients were treated with EVD and 118 with ACE. IVH was the most common diagnosis in the ACE group, whereas SAH and IVH were the most common in the EVD group. IT medications used included alteplase, nicardipine, vancomycin, and tobramycin. Irrigation solutions used in ACE included both lactated ringers and normal saline.

Comparative outcome data are presented in Table 2. Rates of all complications were significantly lower in the ACE group compared with EVD with the exception of insertional hemorrhage and inadvertent removal, which did not differ between groups. ACE therapy was superior to EVD in rates of infection, early replacement, failure to drain, and CSF leak. Patients undergoing ACE were more likely to be at MRS 0 to 2 at discharge and less likely to be shunt dependent. The use of stereotactic navigation was not associated with a lower rate of insertional hemorrhage (odds ratio 0.80, 95% CI, 0.23-2.77, $P = .73$).

DISCUSSION

Complications

ACE therapy was superior to EVD in avoidance of complications including failure to drain, infection, early replacement, CSF leak, and a composite measure of all complications. Inadvertent removal and insertional hemorrhage were not significantly different between groups. These results are consistent with previous reports that have reported low complication rates, even in

TABLE 1. Demographic Data for Patient Cohort

Variable	ACE	EVD
Total, N	118	401
IVH	77 (65.3%)	190 (47.4%)
SAH	35 (29.7%)	201 (50.1%)
Ventriculitis	6 (5.1%)	10 (2.5%)
Age (y)	60.9 ± 0.67	60.2 ± 1.2
Days of treatment	9.3 ± 4.9	9.5 ± 5.8
Admission GCS	9 ± 4	9 ± 5
Preadmission MRS	0	0
Discharge MRS		
Patients with available data	113	397
0	10 (8.8%)	2 (0.5%)
1	11 (9.7%)	14 (3.5%)
2	4 (3.5%)	25 (6.3%)
3	7 (6.2%)	48 (12.1%)
4	31 (27.4%)	112 (28.2%)
5	23 (20.4%)	122 (30.7%)
6	27 (23.9%)	74 (18.6%)
IT medications		
NS/LR	53	
tPA	39	
Nicardipine	10	
Vancomycin	4	
Tobramycin	2	

ACE, active cerebrospinal fluid exchange; EVD, external ventricular drain; GCS, Glasgow Coma Scale; IT, intrathecal; IVH, intraventricular hemorrhage; LR, lactated ringers solution; MRS, modified Rankin score; NS, normal saline; SAH, subarachnoid hemorrhage; tPA, tissue plasminogen activator.
± Denotes SD.

cases with high expected morbidity.¹¹⁻¹⁹ The decrease in complication rates is likely due to the ACE therapy itself because it prevents drain occlusion, which has been associated with complications previously.^{26,27} Complications that are not related directly to ACE therapy itself, such as inadvertent removal and insertional hemorrhages, were not different between groups. This is consistent with the hypothesis that ACE therapy is the driver of lower complication rates as inadvertent removal and hemorrhage are more related to technical factors related to insertion and securing of the drain rather than the drainage therapy itself. Indeed, the only trial to report higher rates of complications using ACE

therapy had multiple technical complications in the ACE group including high rates of inadvertent removal and drain replacement.²² The reported complication rates in that study were plagued by high rates of crossover from the ACE group to the EVD group, limiting conclusions that can be drawn. The results reported there are consistent with our results, that is, when technical factors are similar between the groups, the ACE therapy lowers complication rates commonly associated with EVD treatment. This also emphasizes the importance of refining techniques and treatments before evaluating clinical questions.

Clinical Outcomes

ACE therapy was associated with decreased shunt dependence in our patient population of IVH, SAH, and ventriculitis. Although the ACE group had less shunt dependence in all subgroups tested, the only subgroup that showed a statistically significant difference was the IVH group. This is likely due to insufficient numbers in the ventriculitis and SAH groups. The likely explanation for the lower shunt dependence is the more rapid clearance of cellular/proteinaceous debris from the ventricle and subarachnoid space. This explanation is hypothetical because the retrospective nature of our data prevents direct comparison of those outcomes. Prospective cohort studies and randomized controlled trials will be necessary to confirm an association as well as a possible causal relationship.

There are several pathophysiological factors that can contribute to hydrocephalus after IVH and SAH including oncotic macromolecules, increased CSF production, occlusion of the ventricular system, occlusion of the arachnoid granulations, and decreased venous circulation.^{28,29} Possible mechanisms for the decrease rate of shunting include dilution of macromolecules, increasing dynamic movement of CSF, and faster clearance of physical obstruction by more rapid clearance of intracranial blood clot. A randomized trial specifically designed to evaluate the effect of ACE therapy on hydrocephalus in SAH has been proposed and is currently being planned.³⁰

The other clinical outcome that was assessed in our trial is the likelihood of a functional MRS at discharge (0-2). This was chosen because it is generally a cutoff that determines patients who can be discharged directly to home from the hospital rather than a stay in a skilled nursing facility or rehab. Furthermore, acute interventions in the NCCU are most likely to have their largest effect during the hospital stay rather than over time. This is critical because prolonged recovery times and risk of prolonged recovery are important predictors of withdrawal of life sustaining care for family decision makers. In addition, even patients who have eventual recovery after prolonged rehab have high mortality and limitation of care orders.³¹ Of course, prospective trials, focused on clinical outcomes will be needed to evaluate the effectiveness of ACE in improving clinical outcomes. There is currently a randomized trial enrolling to evaluate the effectiveness of ACE for improving clinical outcomes in IVH specifically.³⁰

TABLE 2. Comparative Outcomes Between Active CSF Exchange Therapy and Standard EVD

Complication	ACE (%)	EVD (%)	OR (95% CI)	P
Any complication	32 (27.1)	224 (55.9)	0.29 (0.19-0.46)	<.0001
Failure to drain	5 (4.2)	69 (17.2)	0.21 (0.08-0.54)	.0004
CSF leak	3 (2.5)	37 (9.2)	0.26 (0.08-0.85)	.0167
Insertional hemorrhage	7 (5.9)	35 (8.7)	0.66 (0.29-1.5)	.328
Inadvertent removal	2 (1.7)	18 (4.5)	0.37 (0.08-1.6)	.166
Infection	7 (5.9)	98 (24.4)	0.20 (0.09-0.43)	<.0001
Early replacement	6 (5.1)	47 (11.7)	0.40 (0.17-0.97)	.0364
Shunt dependence	11 (9.3)	105 (26.6)	0.28 (0.15-0.55)	<.0001
Fisher 3 SAH	1 (12.5)	12 (21.8)	0.51 (0.06-4.68)	.543
Fisher 4 SAH	4 (18.2)	46 (33.3)	0.44 (0.14-1.39)	.155
IVH	4 (4.9)	43 (23.4)	0.18 (0.06-0.52)	.0005
MRS 0-2 at discharge	25 (22.1)	41 (10.3)	2.47 (1.42-4.27)	.001

ACE, active cerebrospinal fluid exchange; CSF, cerebrospinal fluid; EVD, external ventricular drainage; IVH, intraventricular hemorrhage; MRS, modified Rankin score; OR, odds ratio; SAH, subarachnoid hemorrhage.

Limitations

First, this study is a retrospective cohort study using patient data from electronic medical records. This creates a major limitation that certain data elements are missing for different subjects and precise evaluation of different end points becomes impossible. For example, the time to clear the third ventricle of hemorrhage is difficult to assess because many patients did not have standardized imaging to evaluate this outcome. Future approaches should include both randomized trials to evaluate specific clinical questions where equipoise exists and prospective, prespecified registries, where the effects of care can be assessed with standardized treatment and data-collection protocols.

Because of the retrospective design, the treatment groups are ultimately samples of convenience based on nonstandardized treatment allocation. This has resulted in several differences in our treatment groups. Most importantly, the EVD group contains a much higher percentage of SAH patients relative to IVH (201:190 in EVD compared with 35:77 in ACE). In general, SAH is a less morbid disease than IVH, with a consistently lower mortality rate when normalized for GCS.^{1,2} This should bias the complication and clinical outcomes against the ACE group, but the ACE group showed consistently superior outcomes among those evaluated. Nevertheless, different group compositions must be considered when evaluating the results presented here.

Other major group features, including GCS, admission MRS, age, and treatment time, are the same across the treatment groups. The ACE group had much higher rates of IT medications. This is the nature of the different treatments, since ACE therapy makes it convenient and safe to deliver a constant dose of IT medication

while maintaining drainage and keeping the sterile system closed. This ability is not available in EVD treatment, making the use of IT medications more hazardous. It is possible that the use of IT medications, rather than ACE therapy itself, was a major contributing factor to the results reported here. This will need to be evaluated with prospectively designed trials. A trial evaluating this specific question in IVH with ACE therapy and IT alteplase is currently enrolling and will hopefully provide an answer to these questions.³⁰

The choice of treatment used was at the discretion of the treating physician. This affected treatment used, stereotaxy, etc. Thus, the treatment allocation across the groups was not blinded or randomized. This introduces the possibility of bias in treatment allocation. This could take several forms, for example, more skilled physicians could prefer EVD or vice versa, thus creating confounding between the groups not because of the intervention studied here. This must be considered when interpreting our results.

In addition to the items mentioned above, there are several other potential confounding factors for which we were unable to control. Treatment protocols within and across institutions were not controlled for. This means that several important treatment decisions could have potential confounding influence on the outcome. These include different surgeons and intensivist treatment regimens across groups, patients, and institutions. In addition, irrigation and IT medication choices vary at all levels of the included patient populations. It is possible that one specific treatment choice is responsible for differences that we observed and that specific irrigation or IT medication choices could have

opposite results when compared directly with each other. Furthermore, the use of ACE therapy is relatively new, and therefore, patients presenting later in the included time period were more likely to have ACE therapy compared with patients presenting earlier. Patients in the EVD were thus more likely to have presented pre-COVID than those included in the ACE group. The importance of this factor is unknown but cannot be controlled for in our current study design.

Another specific confounding factor is that no use of IT tPA was recorded in the EVD group. IT tPA is a common option for IVH cases, and its lack of utilization in the standard EVD group may exacerbate the differences that we report. That being said, continuous IT tPA through ACE has several technical advantages compared with bolus tPA, chiefly no violation of the sterile system and no interruption in drainage.

Finally, as the IRRAflow device used for ACE therapy was a recent addition to all NCCUs included in this study during the enrollment period, therapeutic intensity may have been higher for those patients as a result of using a new therapy. In this case, the increased attention and care associated with a new device could have contributed to the results that we report here.

Strengths

The biggest strength of this study is the large number of patients included in a study looking at complications related to EVD and ACE therapy. The EVD group included 401 patients, which puts it as one of the largest patient cohorts to address this question. The 118 patients undergoing ACE therapy is a large cohort on its own. Together, the total cohort of 519 patients is likely the largest report of patients requiring intraventricular drainage in the literature. Large, multi-institutional, retrospectively gathered patient cohorts may give the best indication of complication rates that will be seen in practice. Randomized trials are excellent for answering specific clinical questions but may lead to a complication rate lower than that seen in practice because of the rigorous inclusion and exclusion criteria as well as standardized treatment protocols. This also allows a relatively high level of precision, even in a varied clinical scenario, such as the one presented here.

Another strength of this study comes from its retrospective design. Although retrospective studies have several limitations, mentioned above, there are some strengths. The sample gathered from patients who were treated at high-volume NCCUs can give a better representation of the expected clinical outcomes and complications in actual practice. Furthermore, retrospective studies allow the collection of a larger number of subjects in a shorter time period, with less expense than a randomized trial. Finally, the cohorts in retrospective studies are more likely to match the actual cohorts of patients in practice than the carefully selected patients enrolled in a randomized trial.

Finally, this study included centers experienced with the IRRAflow device and with large volume NCCUs. This demonstrates that, despite some treatment variability between physicians and centers, that results in busy centers with experience with the

device can achieve excellent patient outcomes, even at this early stage of technology and treatment development.

Future Directions

This study shows improvement in complications commonly associated with EVD when using ACE therapy with the IRRAflow catheter. This should be followed up with both prospectively designed registry studies and randomized controlled trials. A prospective registry will allow controlling of known confounding variables, while maintaining the advantage of large numbers of patients and measuring actual clinical practice.

The IRRAflow device is a novel treatment that requires significant experience and expertise to achieve the outcomes reported in this study. Improving access to training and technical assistance from peers and the literature is critical in making these outcomes available to patients treated at inexperienced or low volume centers.

Some specific questions will need to be answered by specific randomized trials. One is currently enrolling to determine the benefits of IT alteplase with or without ACE therapy for patients with IVH.³² Another randomized trial is currently in its pre-enrollment stage and will address the risk of hydrocephalus and shunt dependence after SAH treated with ACE therapy.³⁰ As experience with ACE therapy grows and practical experience increases around the world, more specific questions will be raised that will need to be addressed.

ACE therapy also allows safer and more consistent delivery of IT medications. This has allowed more opportunities to study IT medications for a variety of diseases. ACE therapy itself may prove to be of benefit for more diseases than those with frank ventricular contamination reported here. This also demands more knowledge about pharmaceutical stability in dilute continuous irrigation preparations. In addition, the basic physiology of CSF and the brain are able to be studied in new ways than before because dilution and volume can be directly controlled, with concurrent measurement of intracranial pressure.

CONCLUSION

ACE therapy through the IRRAflow catheter seems to lower complication rates associated with EVD, decreases shunt dependence, and increases the likelihood of high-functioning neurological status at discharge. These results are from a retrospective cohort study and must be confirmed with prospective cohort and randomized trials.

Funding

This study did not receive any funding or financial support.

Disclosures

Behnam Rezai Jahromi has received grant funding from IRRAS for ARCH Trial (NCT05118997), which is related to the double lumen

catheter that is used in this study. The trial is not about this reported study. Dr Jahromi is a consultant and owner for Neurovascular Innovations, and has a patent pending on CSF exchange (Not related to technology being discussed in this article). Jeffrey Garavaglia is a paid consultant for IRRAS. Alexandra R. Paul is a consultant for Microvention, receives speaking honoraria from IRRAS, penumbra, and NICO. Ryan M. Hess is a consultant for IRRAS, not related to this study. Elad I. Levy holds shareholder/ownership interest in NeXtGen Biologics, RAPID Medical, Claret Medical, Cognition Medical, Imperative Care (formerly the Stroke Project), StimMed, Three Rivers Medical, Q'Apel, and Dendrite; holds a patent with Ultrasonic Surgical Blade; is a National PI for Penumbra THUNDER, Medtronic SHEILD, Medtronic (formerly Covidien Neurovascular), Steering Committees for SWIFT Prime and SWIFT Direct Trials; is a site PI for MicroVention, CONFIDENCE Study, Medtronic (formerly Covidien Neurovascular), and STRATIS Study – Sub I. Dr Levy has also received honorarium for training and lectures from Medtronic (formerly Covidien Neurovascular), Penumbra, MicroVention, and Integra; is a consultant for Clarion, GLG Consulting, Guidepoint Global, Medtronic (formerly Covidien Neurovascular), StimMed, and Mosaic; is the Chief Medical Officer for Haniva Technology; on the advisory board for NeXtGen Biologics, Cognition Medical, Endostream Medical, and IRRAS AB-Consultant/Advisory Board; holds a leadership or fiduciary role in CNS-Congress of Neurological Surgeons, ABNS-American Board of Neurological Surgery, and UBNS-University at Buffalo Neurosurgery; and is a medical legal review, Expert Witness-Rendering medical/legal opinions. Adnan H. Siddiqui is a Co-investigator for NIH-1R01EB030092-01, Project Title: High Speed Angiography at 1000 frames per second; Mentor for Brain Aneurysm Foundation Carol W. Harvey Chair of Research, Sharon Epperson Chair of Research, Project Title: A Whole Blood RNA Diagnostic for Unruptured Brain Aneurysm: Risk Assessment Prototype Development and Testing. Dr Siddiqui has financial interest/investor/stock options/ownership in Adona Medical, Inc., Basecamp Vascular SAS, Bend IT Technologies, Ltd., BlinkTBI, Inc., Borvo Medical, Inc., Cerebrotech Medical Systems, Inc., CerebrovaKP, Code Zero Medical, Inc., Cognition Medical, Collavidence, Inc., Contego Medical, Inc., CVAID Ltd., E8, Inc., Endostream Medical, Ltd., FreeOx Biotech, SL, Galaxy Therapeutics, Inc., Hyperion Surgical, Inc., Imperative Care, Inc., InspireMD, Ltd., Instylla, Inc., Launch NY, Inc., Neuroolutions, Inc., NeuroRadial Technologies, Inc. (Sold to Medtronic in 2021), Neurovascular Diagnostics, Inc., NeXtGen Biologics, Peijia Medical, PerFlow Medical, Ltd., Physician X, LLC, Piraeus Medical, Inc., Prometheus Therapeutics, Inc., Q'Apel Medical, Inc., QAS.ai, Inc., Radical Catheter Technologies, Inc., Rebound Therapeutics Corp. (Purchased 2019 by Integra Lifesciences, Corp), Rist Neurovascular, Inc. (Purchased 2020 by Medtronic), Sense Diagnostics, Inc., Serenity Medical, Inc., Silk Road Medical, Sim & Cure, Spinnaker Medical, Inc., StimMed, LLC, Synchron, Inc., T.G. Medical, Inc., Tulavi Therapeutics, Inc., Vastrax, LLC, Viseon, Inc., Whisper Medical, Inc., Willow Medtech, Inc. Dr Siddiqui is a consultant for Amnis Therapeutics, Asahi Intecc Co. Ltd., Canon Medical Systems USA, Inc., Cerebrotech Medical Systems, Inc., CerebrovaKP, Cerenovus, Contego Medical, Inc., Cordis, Endostream Medical, Ltd., FreeOx Biotech, SL, Hyperfine Operations, Inc., Imperative Care, InspireMD, Ltd., Integra, IRRAS AB, Medtronic, MicroVention, Minnetronix Neuro, Inc., Peijia Medical, Piraeus Medical, Inc., Prometheus Therapeutics, Inc., Q'Apel Medical, Inc., Rapid Medical, Serenity Medical, Inc., Shockwave Medical, Inc., Silk Road Medical, StimMed, LLC, Stryker Neurovascular, Synchron Australia Pty Ltd., T.G. Medical, Inc., VasSol, Vesalio, Viz.ai, Inc., WL Gore. Dr

Siddiqui is on National PI/Steering Committees for Cerenovus EXCELLENT and ARISE II Trial; Medtronic SWIFT PRIME, VANTAGE, EMBOLISE and SWIFT DIRECT Trials; MicroVention FRED Trial & CONFIDENCE Study; MUSC POSITIVE Trial; Penumbra 3D Separator Trial, COMPASS Trial, INVEST Trial, MIVI neuroscience EVAQ Trial; Rapid Medical SUCCESS Trial; InspireMD C-GUARDIANS IDE Pivotal Trial. Dr Siddiqui holds the following patents: Patent No. US 11,464,528 B2, Date: October 11, 2022, CLOT RETRIEVAL SYSTEM FOR REMOVING OCCLUSIVE CLOT FROM A BLOOD VESSEL, Applicant and Assignee: Neuravi Limited (Galway), Role: Co-Inventor. Nicholas J. Brandmeir received funding from IRRAS. The other authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

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Acknowledgments

Author Contribution: Manuscript preparation: BRJ, GM, JG, NJB. Data Collection: GM, MBK, JOH, AAB, BRJ, MN, NJB, RMH, RCT, JS, PT. Data Analysis: NJB, GM. Manuscript revision/final approval: NJB, GM, AHS, EIL, JG, ARP, BRJ, RCT. West Virginia University Authors: The authors' institution has a current consulting agreement with IRRAS Inc. This work was investigator initiated and prepared with complete independence from IRRAS Inc. and any other funding sources. The first author has a consulting agreement with IRRAS Inc.

COMMENTS

This paper retrospectively examines a multi-center experience with active cerebrospinal fluid exchange via a dual lumen external ventricular catheter. The study enrolled 118 patient who were treated for subarachnoid hemorrhage, intraventricular hemorrhage, and ventriculitis. An additional 401 patients treated with traditional single lumen drainage served as the control group. The dual lumen catheter was associated with lower complications including obstruction and infection.

The concept of continuous ventricular lavage and drug administration is attractive. It is easy to imagine how improved clearance of blood or infection would both be likely to decrease the chance of eventual shunt placement. The dual lumen catheter appears to be comparable to a typical single lumen catheter, and the technique for insertion is no different.

Because the study was retrospective, the authors are not able to determine how the decision was made to use the dual lumens catheter over a single lumen one. Further, it appears that some catheters were placed stereotactically. Without understanding these issues, it is difficult for the reader to exclude both selection bias and performance bias. How can we know that patients receiving the dual lumen device were not destined for a more favorable outcome from the start. It is also possible that they were scrutinized more vigilantly since the authors were not blinded to its use. There may also have been an expectation of superiority when using a new technology. These factors call into question the claim that the dual lumen catheter alone increased the likelihood of better neurological outcome.

I look forward to further prospective work on this device since it sounds very promising.

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