ScientificScholar®
Knowledge is power
Publisher of Scientific Journals

www.surgicalneurologyint.com

Surgical Neurology International

Editor-in-Chief: Nancy E. Epstein, MD, Clinical Professor of Neurological Surgery, School of Medicine, State U. of NY at Stony Brook.

SNI: Spine

Editor
Nancy E. Epstein, MD
Clinical Professor of Neurological Surgery, School of Medicine, State U. of NY at Stony Brook

SNI
Open Access

Review Article

Perspective: Early direct repair of recurrent postoperative cerebrospinal (CSF) fluid leaks: No good evidence epidural blood patches (EBP) work

Nancy E. Epstein[1], Marc A Agulnick[2]

[1]Department of Neurosurgery, Professor of Clinical Neurosurgery, School of Medicine, State University of NY at Stony Brook, and Editor-in-Chief Surgical Neurology International NY and c/o Dr. Marc Agulnick 1122 Frankllin Avenue Suite 106, Garden City, NY 11530, USA,. [2]Assistant Clinical Professor of Orthopedics, NYU Langone Hospital, Long Island, NY, USA. 1122 Franklin Avenue Suite 106 Garden City, NY 11530.

E-mail: *Nancy E. Epstein - nancy.epsteinmd@gmail.com; Marc A Agulnick - marc_agulnick@yahoo.com

***Corresponding author:**
Nancy E Epstein, M.D,
Clinical Professor of Neurosurgery, State University of New York at Stony Brook, NY c/o Dr. Marc Agulnick, 1122 Franklin Avenue Suite 106, Garden City, NY 11530 and Editor-in-Chief of Surgical Neurology International.
nancy.epsteinmd@gmail.com

Received : 28 February 2023
Accepted : 01 March 2023
Published : 31 March 2023

DOI
10.25259/SNI_193_2023

Quick Response Code:

ABSTRACT

Background: "Targeted" epidural blood patches (EBP)" successfully treat "focal dural tears (DT)" diagnosed on thin-cut MR or Myelo-CT studies. These DT are largely attributed to; epidural steroid injections (ESI), lumbar punctures (LP), spinal anesthesia (SA), or spontaneous intracranial hypotension (SICH). Here we asked whether "targeted EBP" could similarly treat MR/Myelo-CT documented recurrent post-surgical CSF leaks/DT that have classically been effectively managed with direct surgical repair.

Methods: Utilizing ultrasound, fluoroscopy, or O-arm guidance, "targeted EBP" effectively manage "focal DT" attributed to ESI, LP, SA, or SICH. Here we reviewed the literature to determine whether similar "targeted EBP" could effectively manage recurrent postoperative CSF leaks/DT.

Results: We were only able to identify 3 studies involving just 20 patients that attempted to utilize EBP to control postoperative CSF fistulas/DT. EBP controlled CSF fistulas/DT in 6 patients in the first study, and 9 of 10 patients (i.e. 90%: 2/2 cervical; 7/8 lumbar) in the second study. However, in the third study, 3 (60%) of 5 EBP failed to avert recurrent CSF leaks/DT in 4 patients (i.e. 1 cervical patient (2 EBP failed attempts), 3 lumbar patients (1 failed EBP)).

Conclusion: Early direct surgical repair of recurrent postoperative spinal CSF leaks/DT remains the treatment of choice. Our literature review revealed 3 underpowered studies including just 20 patients where 20% of EBP failed to control recurrent postoperative fistulas (range of failure from 0-60% per study). Although there are likely other studies we failed to identify in this review, they too are likely insufficiently powered to document significant efficacy for performing EBP over direct surgical repair for recurrent postoperative CSF leaks/DT.

Keywords: Spontaneous intracranial hypotension (SICH), Dural tear (DT), Dural repair, Cerebrospinal fluid (CSF) leak, Epidural blood patch (EBP), Fluoroscopy, Targeted EBP, Myelo-CT, MR, Postoperative recurrent lumbar CSF leaks, Insufficient evidence

INTRODUCTION

"Focal cerebrospinal fluid (CSF) leaks/dural tears (DT)" identified on Myelo-CT and/or thin-cut MR studies are largely attributed to; epidural steroid injections (ESI), lumbar punctures (LP), spinal anesthesia (SA), or spontaneous intracranial hypotension (SICH) [Table 1].[1,3-10,12,13] These "focal leaks" have long been successfully treated with "targeted epidural blood patches (EBP)" utilizing ultrasound, fluoroscopy, or O-arm guidance [Table 1]. Here, however, we reviewed the

Table 1: Data for use of epidural blood patches.

Author Journal Year	Patients Aim of Study	Study Design	Results	Results	Outcomes Conclusions
Olsen[9] **Pain** **1987**	EPB to Rx Post-LP HA Review Tech	How to Treat HA Due to LP	Few Risks or Adverse Events Years Good Results EBP	**Technique** **"…injection of 10-20 ml autologous blood**	**".at the site of the dural puncture-."**
Khan[8] **Spine** **2006**	DT -Lam/F Lumbar 3183 1 Center Postop Early Mobility	DT 1st OR 7.6%-153/2024 Pts Vs. Revision OR 15.9% 185/1159 Pts **Total DT 10.3% (338/3183)**	**6 Recurrent Postop Leaks (6/338=1.8%)** 4 1st OR 2 Revision OR **Not Better with Postop Protocol** Both Required DT Repair+Subfascial Drain-	DT Repair 4-0 Silk Sutures **DT Often Lumbar Surgery** DT 2X More with Revisions	98.2% Success Early Mobility After DT **1.8% -6 Pts Recurrent DT-Repair**
Guerin[7] **Injury** **2012**	**Traumatic Primary DT SS Common** 1326 Pts 1 Center 37 mos. f/o Recurrent CSF Leak Postop	DT 1st OR 51/1326 (3.8%) 1st 2 Cervical 1 ARetrop 48 TL Posterior S	**13 (1%) Postop Adverse Events** ***7 CSF Leaks*** ***2 Pseudom*** 2 SSI, 2 Clots **9/13 Reop** Good Results	**"All incidental durotom-ies must be repaired primarily"**	Immediate REOP DT **".did not lead to any significant sequelae at a mean follow-up of 37 months."**
Clendenen[2] **J Neurosurg Anesthesiol** **2012**	6 Patients ICH/HA LamF CSF Leaks/ DT **Rx 4-D US Guided EBP**	Many Risks of Persistent Postop CSF Leak	**Recommend Early Rx** Surgery Lumbar SA Drain **Less Common EBP**	Absence of LF Use US Guidance Tuohy Needle **Direct to DT Site for EBP Rx**	**All 6 Sx Relief US Guided EBP** Accurately Positioned Tuohy Needle Postop LamF
Epstein[3] **SNI** **2013**	Review Diagnosis Treatment CSF Fistulas/DT During SS	Traumatic DT-Higher Revision SS Due to Scarring	**Causes DT-Traumatic** ESI, OPLL, OYL **Emphasis Early Diagnosis** RIC, MR, Myelo-CT **Early Repair**	DT Repair Technique 7-0 Gore-Tex Sutures, Muscle Patch, MFC FG/FC	RARELY use Lumbar Drains or Lumbar-Peritoneal Shunts
Yoshida[15] **J Neurosurg Spine** **2014**	Myelo-CT Targeted 12 EBP **SIH** CSF Leaks **Etiology** Calcified Disc Osteophyte	**Etiology** OPLL, OYL **8 Spont DT Ventral See Ossification** **4 "Guessed" Local-Maximal Dye Extrav.** 2005-2013	**Use Myelo CT Locate Leak+Document Results Targeted EBP** 8 Ossified Lesion 4 Assumed Local	**Results** **10/12 1 mo. SIH/ HA Resolved** 2 Few Mos. Medical Rx (3 Chronic SDH)	Anterior Calcifi–d -Ossified Lesions **Myelo-CT S–H -DT Best Treated Targeted EBP**

(Contd...)

Table 1: *(Continued).*

Author Journal Year	Patients Aim of Study	Study Design	Results	Results	Outcomes Conclusions
Epstein[4] **SNI** **2015**	Incidence Treatment Postop CSF Fistulas **After 336 Lumbar Lam NIF**	Intraop CSF Fistulas For Lumbar Multilevel Lam-NIF 2000-2015 4.7 Lam 1.4 NIF	Etiology DT 3 Scar, 5 OYL/Trauma 6 Synovial Cysts 7 ESI, 3 IDT Repair 7-0 Gore-Tex micro staples, Muscle patch, FS/FG (Tisseel) , MFC	Without DT Due to ES IDT: **4/2% DT** due to 6 Synovial cysts, 5 OYL- trauma 3 Scarring	**"Knowing the pathologies ...should help .better anticipate and treat these fistulas."**
Takai[13] **World Neurosurg** **2017**	Targeted EBP with O-Arm StNav for **8 SIH**-Ventral CSF Leak- Eval EBP	**Targeted EBP Local of "Presumed" DT Better Outcomes vs. Non-Targeted EBP**	**8 Pts** **Myelo-CT+Thin Cut MR** EBP Under O-ARM StNav- **During EBP No DT Occurred**	Leaks Due Micro Spurs Myelo-CT MR Ventral DT	1st EBP 6/8 Covered Defect 2nd EBP 2 Pts EBP Covered Defect
Pagani-Estevez[10] **Reg Anesth Pain Med** **2019**	Procedural **Predictors EBP Efficacy for SIH** EBP Effective Rx for SICH **202 Patients Received 604 EBP**	78% 1-Level 473 Pts 349 (58%) Lumbar 75 (12%) Bilevel 56 (9%) Multilevel (>/= 3 Levels) **Iatrogenic CSF Leaks Excluded**	**Predict Greater Efficacy Higher volume Bilevel Multilevel Site-Directed Patches More Effective vs. Non-Targeted Patches**	Lower Thoracic+Lumbar Most Success Bilevel (Lasted Median 74 days) Failed EBP Consider Multilevel Transforamen Injection+FG	**Factors 1st EBP > Success > Volume >> Levels Injected Site-Directed** Greater Volume/> Leak Site Covered Advocate > Bilevel+Multilevel Patches
Wong[14] **J Pain Res** **2019**	**Results Targeted EBP for 4 Traumatic DT After SS Using Fluoro** General 1.8% Recurrent Postop SS CSF Leaks	**Limited Data Efficacy EBP Persistent DT CSF Leaks Due to Traumatic SS** Postop SS Recurrent DT No Response Conservative Rx	**4 Pts: 5 EBP** **1 Cervical,** **1 LamF Revision** **2 Lumbar Dec** EBP Used 5-14 cc Autologous Blood- 18 G Needle/ Catheter **MR-Locate DT Site Before Targeted EBP with Fluoro**	**5 EBP/4 Pts** 3 Lumbar *2/3 Better* 2 Cervical *0/2 Better* **Cervical More Difficult to Treat**	**"...targeted EBP can be an effective treatment for CSF leak from incidental durotomies.**
Agulnick[1] **SNI** **2020**	Mini/Micro Bone Suture Anchor Repair Lumbar DT	Primary or Postop/Reop Bone Suture Anchor Repair-No Residual Dural Margin	Used to Suture Fascia, Periosteal Graft, Muscle Grafts, MFC (sutured/ nonsutured) +Tisseel/FS	Avoids Need to Place Lumbar Drains or LP Shunts	Direct Suture Dural Grafts Use Bone Suture Anchor Repair DT

(Contd...)

Table 1: *(Continued).*

Author Journal Year	Patients Aim of Study	Study Design	Results	Results	Outcomes Conclusions
Gandhi[6] **Int J Neurosci** **2021**	CSF Leaks Due to DT Trauma, SS LP, ESI, Meningeal Disease	DT Cause ICH/ Positional HA	**Treatment EBP** Epidural Infusions Epidural Fibrin Glue (FG) Surgical Repair	**"At this time, epidural blood patches are the first line of treatment"**	Highest Frequency DT After SS Develop Protocol for Recognition/Rx
Epstein[5] **SNI** **2021**	SS-Early Diagnosis Rx Postop DT/CSF Leaks<3-4 wks. Avoid AA 1st SS DT Lumbar 8.7-9.5%	**Recurrent Postop DT Lumbar Surgery 8.1%-17%** Diagnose Postop DT with MR Myelo-CT	**Diagnosis AA** Root Clumping Empty Canal Thecal Sac Sign Soft Tissue Mass Compartments	Rx DT Rare Ineffective EBP FS FG **Need Direct Surgical Repair-**	**OR: Scope 7-0 Gore-Tex Sutures, Mini Staples Muscle Graft Suture Anchors, MFG, FS, FG**
Phan[11] **World Neurosurg** **2022**	Incidental SS DT Typical Rx Bed Rest	Postop 1392 Pts Avg age 56.3	Persistent Postop CSF Leaks **2 Cervical**	**EBP Rate Success** 9/10 (90%) Resolved Sx	**"Targeted epidural blood patch is effective in treating**
	Repeat Surgery **Other Option EBP**1 1 Center 2012-2020 SS	Cervical 435 TL 956 **Intraop DT** 6 (1.4%) Cervical 64 (6.7%) Lumbar 70 (5%) DT-Blebs	(33.3% or 2/6) Recurrence) **8 Lumbar** (6% or 8/134) Recurrence	1 Lumbar Pt Failed -1st EBP, Failed Reop. 2nd EBP Succeeded	**symptomatic CSF leaks"** Argues Avoids Reop
Shin[12] **Anesth Pain Med (Seoul)** **2022**	EBP for SIH-HA Due to Low CSF Pressure	Manage SIH/ Postural Headaches with EBP	Careful Planning with C-Arm Fluoroscopy	EBP May Be Associated with "serious complica-tions"	"However, **Prophylactic administration of EBP after accidental dural puncture can hardly be substantiated at present**"
Zetlaoui[16] **Anaesth Crit Care Pain Med** **2022**	EBP One of the Most Effective Rx for ICH	**Anes Perform EBP for:** DP/DT ICH After Spinal Anesthesia Epidural Anesthesia, LP	EBP Also Used to Rx SIH	**Monitor Objective Evidence for Efficacy of EBP** MR Doppler US	Improve Future Accuracy Efficacy EBP

EBP: Epidural blood patch, CSF: Cerebrospinal fluid, ICP: Intracranial pressure, HA: Headache, SIH: Spontaneous intracranial hypotension, PDPH: Post dural puncture headaches, DP: Dural puncture, Anes: Anesthesia, Comp: Complication, Rx: Treatment, ICH: Intracranial hypotension, LP: Lumbar punctures, Diag: Diagnostic, US: Ultrasound, AE: Adverse event, DT: Dural tears, SALD: Subarachnoid lumbar drain, MIS: Minimally invasive, TL: Thoracolumbar, Sx: Symptoms, Pt: Patient. Intraop: Intraoperative, ESI: Epidural Steroid Injections, LF: Lumbar Fusion, Rev: Revision, Dec: Decompression, Pneumo: Pneumocephalus, LF: Ligamentum flavum, LamF: Laminectomy with fusion, SNI: Surgical Neurology International, AA: Adhesive arachnoiditis, ESI: Epidural steroid injections, OPLL: Ossification posterior longitudinal ligament, OYL: Ossification yellow ligament, RIC: Radioisotope cisternography, LAM: Laminectomies, NIF: Non-instrumented fusion, IDT: Intradural tumors, f/o: Follow-Up, Retrop: Retroperitoneal, Pseudom: Pseudomeningoceles, Deg: Degenerative, StNav: Stereotactic navigation, Eval: Evaluation, Spont: Spontaneous, SDH: Subdural hematomas, Tech: Technique, OR: Operations, ARetrop: Anterior retroperitoneal, SS: Spine surgery, ICH: Intracranial hypotension, Sx: Symptoms, MFC: Microfibrillar collagen, FS: Fibrin sealant, FG: Fibrin glue, Extrav.: Extravasation

literature to determine whether "targeted EBP", rather than classically accepted direct surgical repair strategies, could effectively treat recurrent postoperative/post-surgical CSF leaks/DT.[2,11,14]

Table 2: Studies advocating repair of intraoperative/postoperative cerebrospinal fluid (CSF) leaks/dural tears (DT).

Author Journal Year	Patients Aim of Study	Study Design	Results	Results	Outcomes Conclusions
Khan[8] **Spine** **2006**	DT-Lam/F Lum 3183 1 Center Early Mobility	**DT 1st OR** 7.6% Pts 153/2024 Rev OR 15.9% 185/1159	**6 Recurrent Postop Leaks** **(6/338=1.8%)** 4 1st OR 2 Revision OR	6 Repaired 4-0 Silk Sutures	98.2% Success Early Mobilization **6 (1.8%) Recurrent DT** **Need Direct-Repair**
Guerin[7] **Injury** **2012**	Traumatic Primary DT Often SS 1326 Pts 1 Center Rx Postop DT Recur	DT 1st OR 51/1326 (3.8%) 1st 2 Cervical 1 ARetrop 48 TL Posterior	**13 (1%) Postop Adverse Events** ***7 CSF Leaks*** ***2 Pseudom*** 2 SSI, 2 Clots **9/13 (0.67%) Reop DT**	**"All incidental durotom-ies must be repaired primarily"** **Good Result**	Immediate REOP DT **"...did not lead to any significant sequelae at a mean follow-up of 37 months."**
Epstein[3] **SNI** **2013**	Review Rx SS CSF Leaks DT **Causes DT-** ESI, OPLL, OYL, SS **Trauma**	Traumatic DT-Higher Risk SS Rev	**Early Diagnosis** **Postop DT** RIC, MR, Myelo-CT **Early Repair**	DT Repair Technique 7-0 Gore-Tex Sutures, Muscle Patch Graft, MFC FG/FC	RARELY use Lumbar Drains or Lumbo-Peritoneal Shunts
Epstein[4] **SNI** **2015**	Diagnosis Treatment Postop CSF Fistulas/DT **336 Lum Lam NIF**	Intraop CSF Fistulas For Multilevel Lam-NIF 2000-2015	**Primary Repair 7-0 Gore-Tex micro staples, Muscle Patch, FS/FG (Tisseel) , MFC**	DT Minus 7 ESI, 3 IDT: **4.2%-6 Synovial cysts, 5 OYL, 3 Scar**	"Knowing the pathologies .should help .better anticipate and treat these fistulas." **0% Reop for Recurrent Postop DT**
Epstein[5] **SNI** **2021**	Diagnose Early DT 3-4 wks. Postop Avoid AA Use MR Myelo-CT	1st OR DT Lumbar 8.7-9.5% **Recurrent Postop DT Lumbar 8.1%-17%**	**Diagnose AA** Roots Clumped Empty Canal Soft Tissue Mass Compartments	**Need Direct Surgical Repair** 1st or 2nd DT Ineffective EBP FS FG	**Surgery DT : Microscope, 7-0 Gore-Tex Sutures, Mini Staples, Muscle Graft** **Suture Anchors, MFG, FS, FG**

EBP: Epidural blood patch, CSF: Cerebrospinal fluid, PDPH: Post dural puncture headaches, Rx: Treatment, ICH: Intracranial hypotension, DT: Dural tears, Pt: Patient. Intraop: Intraoperative, Rev: Revision, Dec: Decompression, SNI: Surgical Neurology International, AA: Adhesive arachnoiditis, Lam: Laminectomies, NIF: Non-instrumented fusion, IDT: Intradural tumors, Retrop: Retroperitoneal, Pseudom: Pseudomeningoceles, Deg: Degenerative, OR: Operations, SS: Spine surgery, Sx: Symptoms , MFC: Microfibrillar collagen, FS: Fibrin sealant, FG: Fibrin glue

Symptoms and Etiology of Intracranial Hypotension

Patients may present with classical symptoms/signs of intracranial hypotension (ICH) due to newly occurrent or recurrent CSF leaks/DT [Table 1].[1-16] These symptoms typically include; postural headaches, nausea/vomiting, visual complaints/double vision, difficulty concentrating, lumbar radiculopathy/cauda equina syndromes, sphincter dysfunction, and/or sexual dysfunction.[2-9] CSF leaks/DT are largely documented on thin-cut MR or Myelo-CT studies following prior epidural spinal injections (ESI), lumbar punctures (LP), spinal anesthesia (SA), spontaneous intracranial hypotension (SICH), or trauma due to surgery.[3-5,12-14] Those with "focal DT" attributed to ESI, LP, SA, and SICH are often successfully treated with "targeted EBP" performed under ultrasound, fluoroscopy, or O-arm guidance.[7-9,12-14] Alternatively, patients with surgically induced initial intraoperative, and/or postoperative recurrent CSF fistulas/DT, that are more variable in size/location, are classically managed with direct surgical repairs [Table 2].[3-5,7,8] In our review, we were only able to find 3 underpowered studies that failed to adequately document the efficacy of "targeted EBP" in treating recurrent postoperative CSF fistulas/DT [Tables 1-3].[2,11,14]

Primary or Recurrent Postoperative CSF Fistulas/DT Warranting Direct Surgical Repair

The rates for primary intraoperative (3.0 - 27%) and recurrent postoperative CSF leaks/DT (1.8 - 17.6%) varies [Tables 1 and 2].[3-5,7,8,11,13,15,16] Khan *et al.* (2006) noted a 7.6%

Table 3: Advocates of epidural blood patches to repair of post-surgical CSF leaks.

Author Journal Year	Patients Aim of Study	Study Design	Results	Results	Outcomes Conclusions
Clendenen[2] **J Neurosurg Anesthesiol** **2012**	6 Patients LamF DT US Guide EBP	Risks Postop DT-**CSF Leaks**	**Options Rx:** Repair, Lumbar Drains, **"Less Common EBP"**	US Guided Tuohy Needle **DT Site- EBP**	**6 Success DT US-Guide EBP**
Wong[14] **J Pain Res** **2019**	4 Targeted EBP Persist Post Trauma (Recurrent) CSF Leak- MR Define DT	Fluoro Guided EBP Used 5-14 cc Autologous Blood- 18 G Needle/Catheter	4 Pts 1 Cervical 1 1 LamF Revised 2 Lumbar Dec	**3 of 5 EBP (60%) Failed** 2/2 Cervical 1/3 Lumbar **Cervical Rx>Difficult**	**"...targeted EBP can be an effective treatment for CSF leak from incidental durotomies"**
Phan[11] **World Neurosurg** **2022**	Traumatic Postop DT Options Rx Bed Rest Repeat Surgery EBP 1 Center 2012-2020	1392 Pts Cerv 435 TL 956 1st OR DT 6 (1.4%) Cerv 64 (6.7%) Lum 70 (5%) Blebs (TL)	**Persistent Postop CSF Leaks** **2 Cervical** **8 Lumbar**	**EBP Success 9/10 (90%)** 1 Lum Failed 1st EBP, Reop, Failed, 2nd EBP Success	**"Targeted epidural blood patch is effective in treating symptomatic CSF leaks"**

Cerv: Cervical, Lum: Lumbar, DT: Dural Tears, Rx: Treatment, EBP: Epidural blood patch, CSF: Cerebrospinal fluid, Reop: Reoperations, TL: Thoracolumbar, Fluoro: Fluoroscopic, G: Gauge, Pts: Patients, LamF: Laminectomy Fusion, Dec: Decompression, US: Ultrasound, Postop: Postperative, MR: Magnetic resonance imaging

(153/2024 patients) incidence of primary intraoperative DT (i.e. no history of prior surgery) vs. a much higher 15.9% for revision procedures (185/1159 patients); an additional 6 (1.8%) patients developed recurrent postoperative leaks that were successfully surgically repaired.[8] Primary rates of DT in Guerin *et al.* (2012) spinal series was 3.8% (i.e. 51/1326: 2 cervical, 1 retroperitoneal, and 48 thoracolumbar); secondary postoperative DT occurred in 9 of 51 (17%) patients (i.e. 7 postoperative recurrent CSF fistulas, and 2 pseudomeningoceles).[7] In a review article in 2013, Epstein found a 3.0-27% incidence of primary intraoperative CSF fistulas occurring during multilevel lumbar laminectomies with non-instrumented spinal fusions.[3] Epstein found that other authors further recommended using; "...radioisotope... cisternography (RIC), MR and CT" scans to diagnose the extent/location of postoperative DT.[3] In Epstein's 2015 study, she encountered intraoperative DT in 7.14% of 336 patients undergoing multilevel laminectomies/non-instrumented fusions; the rate was reduced to 4.2% (i.e. 3 for scarring, 6 for synovial cysts resection, and 5 for ossification of the yellow ligament penetrating the dura) once the 7 attributed to ESI and 3 to intradural tumors with deliberate durotomies were excluded.[4] Notably, all patients underwent direct intraoperative surgical repair of DT, and none exhibited recurrent postoperative CSF fistulas/DT. Further, in 2021, Epstein emphasized how critical it is to perform early (i.e. within 3-4 postoperative weeks) direct repair of recurrent postoperative DT to avoid adhesive arachnoiditis, and other adverse events (i.e. acute/subacute/chronic intracranial hypotension (ICH), infection, subdural hematomas, and others).[5]

Direct Dural Repair Techniques Address Primary/ Recurrent Postoperative CSF Fistulas/DT

In multiple studies, patients underwent primary intraoperative and/or recurrent postoperative direct surgical repair of CSF leaks/DT [Tables 1 and 2].[1,3-5,7,8] Khan *et al.* (2006) successfully treated intraoperative CSF leaks/DT occurring in 7.6% primary (no prior surgery) vs. 15.9% revision-procedure CSF leaks/DT, and 6 recurrent postoperative DT (1.8%: 2 after primary, and 4 after revision surgery) utilizing 4-0 Silk sutures.[8] Guerin *et al.* (2012) advocated direct dural repairs for 51 of 1326 (3.8%) primary surgical, and 9 secondary repairs (i.e. 7 for postoperative recurrent CSF fistulas and 2 with pseudomeningoceles).[7] They observed; "All incidental durotomies must be repaired primarily, and that following this regimen resulted in no 'long term sequelae' (over 37 postoperative months)".[7] In 3 studies, Epstein advocated direct "open" dural repair of recurrent postoperative lumbar CSF leaks/DT using 7-0 Gore-Tex sutures (i.e. sutures larger than needles occlude dural punctures), muscle patch grafts, fibrin sealant, and nonsuturable/suturable microfibrillar collagen.[3-5] Further, these procedures should be performed under an operating microscope with intraoperative somatosensory evoked

potentials and electromyographic monitoring to avoid inadvertent cauda equina and/or nerve root manipulation. Only rarely should lumbar drains be used to treat complex fistulas as once removed, they leave large dural holes that risk recurrent fistulas; alternatively, lumboperitoneal shunts with horizontal vertical valves should be considered. In 2020, Agulnick, Cohen, and Epstein additionally advocated using mini/micro bone suture anchors to repair difficult lumbar DT with absent lateral dura; it allowed for suturing the fascia, periosteum, muscle grafts and suturable microfibrillar collagen to the lateral laminectomy walls, thus facilitating "water-tight" closures.[1]

"Targeted" EBP Performed Under Ultrasound, Fluoroscopy, or O-Arm Guidance

EBP involve the epidural injection of a small volume of autologous blood (i.e. 5-20 cc) to occlude a CSF fistulas/DT [Tables 1 and 2].[2,6,9,12-14] In 1987, Olsen performed EBP using 10-20 cc of autologous blood that they directly injected onto the epidural site of a DT.[9] They considered EBP: "... an effective and safe method with few and generally mild complications." Clendenen *et al*. (2012) used 4-D ultrasound guidance to successfully perform 6 "targeted EBP" in patients with recurrent postoperative DT.[2] Takai *et al*. used O-arm stereotactic navigation to perform and monitor the results of their 12 successful "targeted EBP".[13] Wong *et al*. (2019) performed contrast enhanced, fluoroscopically-guided "real time targeted EBP" using 18 gauge needles/catheters and 5-14 cc of autologous blood to treat 4 recurrent postoperative DT (i.e. 1 cervical, and 3 lumbar); here, however, 3 of 5 EBP attempts failed (rate 60%).[14] Gandhi *et al*. (2021) considered "EBP, epidural infusions, epidural fibrin glue or surgical repair" as options to treat DT attributed to lumbar punctures, trauma, or surgery.[6] They further noted; "At this time, epidural blood patches are the first line of treatment."[6] Notably, Shin *et al*. (2022) most recently emphasized the utility of EBP for treating "focal DT" attributed to ESI, SA, LP and SICH; they further utilized MR or ultrasound guidance to directly document their efficacy.[12] Nevertheless, they also cautioned; "Prophylactic administration of EBP after accidental dural puncture can hardly be substantiated at present."

Several Studies Documented SICH Were Effectively Treated With "Targeted EBP"

For SICH, Myelo-CT and thin-cut MR studies documented that DT were effectively treated with ultrasound, fluoroscopy, and/or O-arm guided "targeted EBP" [Tables 1 and 2][10,13,15,16] In Yoshida *et al*. (2014) 12 patients with SICH, 8 leak sites were documented on Myelo-CT studies, while the remaining 4 were inferred based upon the location of "maximal (epidural) dye extravasation"; following "targeted EBP", low pressure headaches immediately resolved in 10/12 patients, while they took several months to improve/resolve in 2 patients [Table 1].[15] Takai *et al*. (2017) 8 patients with SICH (i.e. defined by Myelo-CT/thin cut MR) underwent O-arm guided "targeted EBP"; 6 of 8 succeeded on the first injection, while it took 2 injections performed under the same anesthesia in the other 2 patients (i.e. O-arm immediately documented inadequate coverage from the 1st injection warranting the second) [Table 1].[13] Pagani-Estevez (2019) documented for 604 EBP performed in 202 patients with SICH that higher volumes, bilevel, and multilevel "site-directed" EBP were more successful (i.e. lumbar 349 (58%), 75 (12%) bilevel, and 56 (9%) 3 or more level procedures).[10] Further, Zetaloui *et al*. (2022) recommended using MR or doppler ultrasound after EBP to document/confirm the accuracy, efficacy, and/or adverse events following these procedures.[16]

Adverse Events Resulting From Epidural Blood Patches (EBP) to Treat Post LP Dural Punctures

Adverse events (AE) resulting from the application of EBP may include; complications of blood directly entering the CSF pathways, (i.e. sterile meningeal response, adhesive arachnoiditis, and hydrocephalus with cephalad migration amongst others), infection, abscess formation, direct neural compression (i.e. potential for acute cauda equina syndrome), creation of additional sites of dural puncture, and persistent intracranial hypotension [Table 1].[9,12,13]

Lack of Evidence that EBP "Effectively" Treat Recurrent Postoperative Lumbar CSF Fistulas/DT

The 3 studies we were able to identify in the literature involving just 20 patients did not document the efficacy for utilizing EBP to treat recurrent postoperative CSF leaks/DT [Table 3].[2,11,12,14] Clendenen *et al*. (2012) noted 3 treatment options for patients following lumbar laminectomies/fusions who developed recurrent postoperative CSF fistulas/DT; although these included early direct dural repair, and lumbar subarachnoid drains, they chose the third option - to perform the "less commonly (*used*) epidural blood patches".[2] They then performed 6 "targeted EBP" under 4-D "real-time" ultrasound guidance, and successfully treated recurrent postoperative CSF leaks/DT in all 6 patients. Wong *et al*. (2019) performed 5 "targeted EBP" for 4 patients with recurrent postoperative CSF leaks/DT under fluoroscopic guidance.[14] However, they commented that there were "limited data" regarding the efficacy of using EBP in this setting; 3 (60%) of 5 EBP failed (i.e. 2 EBP failed in 1 cervical, 1 EBP failed in 3 lumbar cases). Nevertheless, they ignored their own findings as they wrongly concluded that; "..targeted EBP can be an effective treatment for CSF leaks from incidental durotomies".[14] In Phan *et al*. (2022) 10 of 1392 patients undergoing spinal procedures, developed recurrent postoperative CSF fistulas/DT and were treated with

EBP; these successfully resolved following 2 of 2 cervical and 7 of 8 lumbar procedures (i.e. 90% success rate).[11] They concluded that the; "Targeted epidural blood patch is effective in treating symptomatic CSF leaks." Nevertheless, Shin *et al.* recently commented that the; "...prophylactic administration of EBP after accidental dural puncture can hardly be substantiated at present" [Table 1].[12] In summary, these 3 studies documented a 20% overall failure rate in just 20 patients (i.e. 4/20; up to 60% failure rate in one study) when EBP were used to treat recurrent postoperative CSF leaks/DT.[2,11,12,14]

CONCLUSION

Epidural blood patches (EBP) successfully treat "focal DT" largely attributed to epidural steroid injections (ESI), lumbar punctures (LP), spinal anesthesia (SA) or spontaneous (SICH). Here, however, as we found insufficient evidence in the 3 studies we identified to support utilizing EBP rather than the classically accepted direct dural repair techniques to treat recurrent postoperative CSF leaks/DT.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Agulnick MA, Cohen BR, Epstein NE. Unique Bone suture anchor repair of complex lumbar cerebrospinal fluid fistulas. Surg Neurol Int 2020;11:153.
2. Clendenen SR, Pirris S, Robards CB, Leone B, Nottmeier EW. Symptomatic postlaminectomy cerebrospinal fluid leak treated with 4-dimensional ultrasound-guided epidural blood patch. J Neurosurg Anesthesiol 2012;24:222-5.
3. Epstein NE. A review article on the diagnosis and treatment of cerebrospinal fluid fistulas and dural tears occurring during spinal surgery. Surg Neurol Int 2013;4:S301-17.
4. Epstein NE. Incidence and management of cerebrospinal fluid fistulas in 336 multilevel laminectomies with non instrumented fusions. Surg Neurol Int 2015;6:S463-8.
5. Epstein NE. Perspective: Early diagnosis and treatment of postoperative recurrent cerebrospinal fluid fistulas/dural tears to avoid adhesive arachnoiditis. Surg Neurol Int 2021;12:208.
6. Gandhi J, DiMatteo A, Joshi G, Smith NL, Khan SA. Cerebrospinal fluid leaks secondary to dural tears: A review of etiology, clinical evaluation, and management. Int J Neurosci 2021;131:689-95.
7. Guerin P, El Fegoun AB, Obeid I, Gille O, Lelong L, Luc S, *et al.* Incidental durotomy during spine surgery: Incidence, management and complications. A retrospective review. Injury 2012;43:397-401.
8. Khan MH, Rihn J, Steele G, Davis R, Donaldson WF, Kang JD, *et al.* Postoperative management protocol for incidental dural tears during degenerative lumbar spine surgery: A review of 3,183 consecutive degenerative lumbar cases. Spine (Phila Pa 1976) 2006;31:2609-13.
9. Olsen KS. Epidural blood patch in the treatment of post-lumbar puncture headache. Pain 1987;30:293-301.
10. Pagani-Estevez GL, Cutsforth-Gregory JK, Morris JM, Mokri B, Piepgras DG, Mauck WD, *et al.* Procedural predictors of epidural blood patch efficacy in spontaneous intracranial hypotension. Reg Anesth Pain Med 2019 Jan 13;rapm-2018-000021.
11. Phan A, Shah S, Joo P, Mesfin A. Can cervical and lumbar epidural blood patches help avoid revision surgery for symptomatic postoperative dural tears? World Neurosurg 2022;164:e877-83.
12. Shin YH, Recent update on epidural blood patch. Anesth Pain Med (Seoul) 2022;17:12-23.
13. Takai K, Taniguchi M. Targeted epidural blood patch under O-arm-guided stereotactic navigation in patients with intracranial hypotension associated with a spinal cerebrospinal fluid leak and ventral dural defect. World Neurosurg 2017;107:351-7.
14. Wong AK, Rasouli MR, Ng A, Wang D. Targeted epidural blood patches under fluoroscopic guidance for incidental durotomies related to spine surgeries: A case series. J Pain Res 2019;12:2825-33.
15. Yoshida H, Takai K, Taniguchi M. Leakage detection on CT myelography for targeted epidural blood patch in spontaneous cerebrospinal fluid leaks: Calcified or ossified spinal lesions ventral to the thecal sac. J Neurosurg Spine 2014;21:432-41.
16. Zetlaoui PJ, Buchheit T, Benhamou D. Epidural blood patch: A narrative review. Anaesth Crit Care Pain Med 2022;41:101138.

How to cite this article: Epstein NE, Agulnick MA. Perspective: Early direct repair of recurrent postoperative cerebrospinal (CSF) fluid leaks: No good evidence epidural blood patches (EBP) work. Surg Neurol Int 2023;14:120.