

Subdural Hematoma: An Update on Diagnosis and Management

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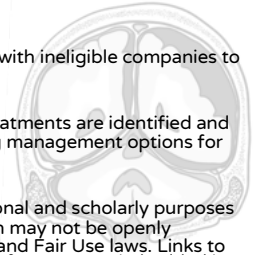


Original image by T. Scruton

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Disclosures

- I have no relevant relationships with ineligible companies to disclose in the last 24 months.
- Off-label and investigational treatments are identified and discussed in review of emerging management options for this condition.
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Learning Objectives

- Recognize common presenting features and risk factors for developing subdural hematoma (SDH)
- Review the pathophysiology and diagnosis of SDH
- Discuss the impact of antithrombotic drugs on SDH
- Review current and emerging treatments for SDH

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Subdural Hematoma (SDH)

- Potentially life-threatening intracranial hemorrhage
- Collection of blood products and inflammatory fluid between the dura and arachnoid covering of the brain
- Occurs with 11–20% of head injuries¹
- Presentations manifest a spectrum of acute to chronic SDH

1. Dennis D, Rocha E, Park M, Lee J, Dyer A, Dwyer AB. Subdural Hematoma: Predictors of Outcome and a Guide to Guide Surgical Decision-Making. J Stroke Cerebrovasc Dis. 2020;30(10):e20388. doi:10.1097/JSC.0000000000000200

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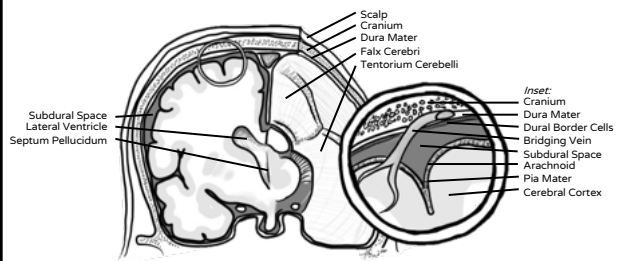
Epidemiology of SDH

- Increasing with age, > 65 years^{1,2}
- Rate increases directly associated with advancing age
- Men > women: ~ 3:1^{3,4}
- Head injury, most commonly FFSH²
- Increased with anticoagulant/antithrombotic meds³
- Projected incidence will nearly double by 2030, becoming the most common cranial neurosurgical condition in the U.S.³

1. Wang J, Liu Y, Han Y, Han Y, Han Y, Han Y. Rates of Discharge Operation for Isolated Subdural Hematoma Among Older Adults. JAMA Netw Open. 2017;1(10):e170372. doi:10.1001/jamanetworkopen.2017.3752
2. Moushey D, Gagnier B, Serran C, et al. Acute subdural hematomas in the elderly: to operate or not to operate? A systematic review and meta-analysis of outcomes following surgery. BMJ Open. Dec 3 2021;15(12):e026102. doi:10.1136/bmjopen-2021-026102
3. Han Y, Li J, Han Y, et al. The Burden of Isolated and Projected Incidence Rates for Chronic Subdural Hematomas in United States Veterans: Admission and Outpatient Populations. J Neurotrauma. 2019;36(18):1928-1938. doi:10.1089/neuro.2018.0190
4. Henry J, Arnold M, Kwon M, et al. Management of Chronic Subdural Hematoma: A Systematic Review and Comparison Network Meta-analysis of 455 Studies With 103 645 Cases. Neurosurgery. Sep 28 2023;doi:10.1227/NEU.0000000000001000

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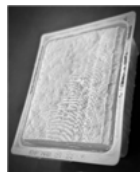
SDH Pertinent Anatomy Review



Original image by T. Scruton

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Tofu in a Tub



Original image by T. Scotton

- Head trauma in the setting of increased subdural space:
- Age-related atrophy and friable bridging veins¹
- Cerebrospinal fluid (CSF) overdrainage²
- Controversial if enlargement of extra-axial space increases SDH risk in children³

1. Goknur VB, Garg N, Agrawal D, Chandra PC, Kulkarni SS. Risk Factors for Progression of Conservatively Managed Acute Traumatic Subdural Hematoma: A Systematic Review and Meta-Analysis. *World Neurology*. 2021; 12(4):312-321. doi:10.5536/wjnc.v12i4.312-321

2. Deak WJ, Sackman CL, Simon AJ, et al. Ventriculoperitoneal shunt complications in an adult population: A comparison of various shunt designs to prevent overdrainage. *Surg Neurol Int*. 2020;11:269. doi:10.31773/S2688-2567.20.0002

3. Koyama H, Chikada C, Kuroki T, Ohtsuka T, Fujikawa AN, Wood J. Subdural hemorrhage in pediatric patients with enlargement of the subarachnoid space. *J Neurosurg Pediatr*. Apr 2013;104:438-44. doi:10.3171/2012.10.PEDS.12989

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Pediatric SDH

- Pediatric patients with enlarged subarachnoid space had been thought to have increased risk of SDH¹
- Recent studies dispute this hypothesis^{1,2}
- In children < 3-years-old the clinical triad of:
SDH
retinal hemorrhages
non-cranial fracture
 predicts abuse / non-accidental trauma²

1. Mahaling S, Chandra C, Raju D, Chinnai C, Palank AN, Wood J. Subdural hemorrhage in pediatric patients with enlargement of the subarachnoid space. *J Neurosurg Pediatr*. Apr 2013;102:438-44. doi:10.3171/2012.10.PEDS.12989

2. Mahaling S, Chandra C, Raju D, Chinnai C, Palank AN, Wood J. Subdural hemorrhage, retinal hemorrhage, and fracture triad as a clinical predictor for the diagnosis of child abuse. *J Neurosurg Pediatr*. Dec 1 2003;17:100-105. doi:10.3171/2003.17.PEDS.0312

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Classical Signs and Symptoms

Complaints	Exam Findings
Headache	GCS < 15
Confusion	Pupil reactivity changes
Nausea	Pronator drift/hemiplegia
Falls/imbalance	Gait changes
Disordered speech/repetition	

Severity on presentation correlates with worse outcomes

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Neurologic Deficits

- Neurologic deficits may result from:
 - Mechanical obstruction to blood flow
 - Seizure
 - Cortical spreading depression
- Atrophic cerebrum may accommodate a large SDH
- Sudden changes have greater effect:
 - Rebleeding
 - Acute hemorrhage

Blount J, Zander SM, de la Vega MM, et al. Pathophysiology of transient neurological deficit in patients with chronic subdural hematomas: A systematic review. *Acta Neurol Scand*. Jan 2022;146(1):49-67. doi:10.1111/ane.15117

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Imaging-based Diagnosis

- Non-contrast CT is preferred initial study¹
- Broad differential diagnosis (DDx)
 - MRI for evaluation of DDx¹

1. Radiology ACS Appropriateness Criteria - Neurologic. Accessed 10/4/22. <https://www.aacr.org/~/media/Assets/2022/09/2022-09-01-Neurologic-Appropriateness-Criteria.pdf>

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SDH Etiologies

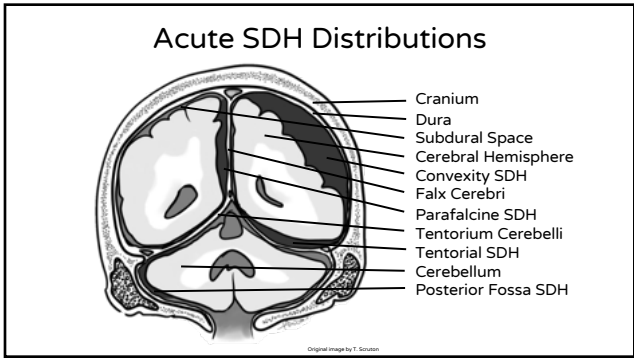
Trauma	
Coagulopathy	Infection / meningitis
Neoplasm	Alcohol or cocaine use
Intracranial hypotension (CSF leak, shunt overdrainage)	Hypovitaminosis: especially vitamin C
Vascular malformation or aneurysm	Hypertension

Goknur VB, Garg N, Agrawal D, Chandra PC, Kulkarni SS. Risk Factors for Progression of Conservatively Managed Acute Traumatic Subdural Hematoma: A Systematic Review and Meta-Analysis. *World Neurology*. 2021; 12(4):312-321. doi:10.5536/wjnc.v12i4.312-321

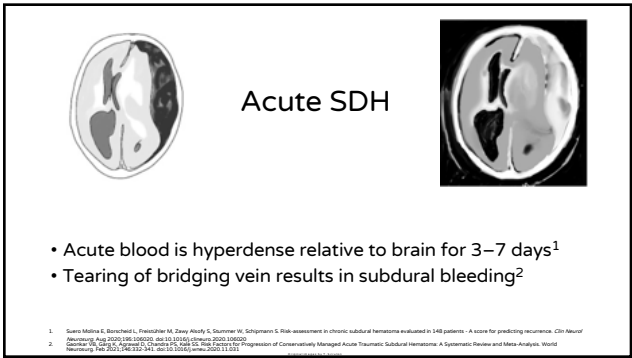
Deak WJ, Sackman CL, Simon AJ, et al. Ventriculoperitoneal shunt complications in an adult population: A comparison of various shunt designs to prevent overdrainage. *Surg Neurol Int*. 2020;11:269. doi:10.31773/S2688-2567.20.0002

Koyama H, Chikada C, Kuroki T, Ohtsuka T, Fujikawa AN, Wood J. Subdural hemorrhage in pediatric patients with enlargement of the subarachnoid space. *J Neurosurg Pediatr*. Apr 2013;104:438-44. doi:10.3171/2012.10.PEDS.12989

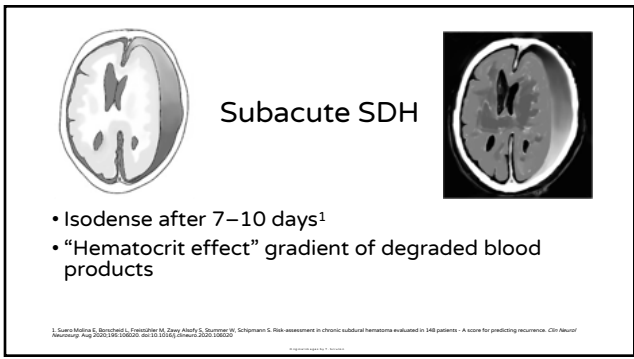
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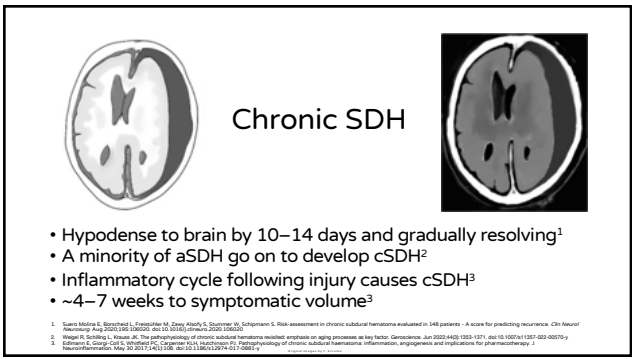
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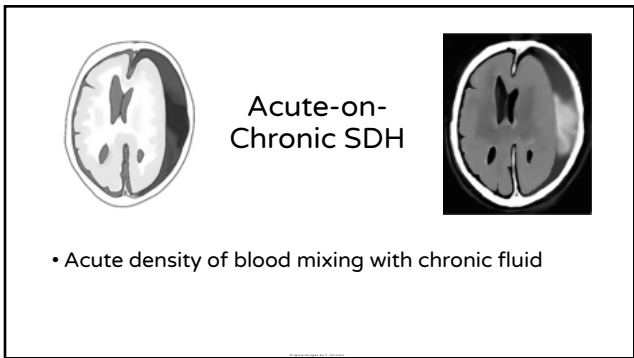
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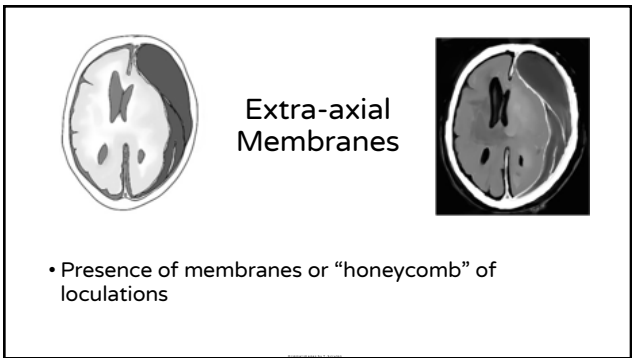
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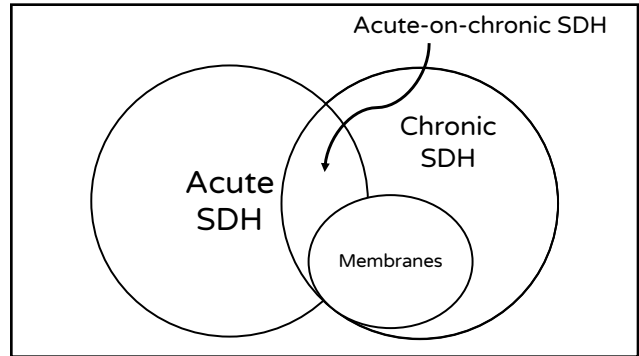
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Type	Diagram	CT	Description
Acute SDH			Hyperdense to brain
Subacute SDH			Isodense to brain "hematocrit effect" density gradient of SDH
Chronic SDH			Hypodense to brain
Acute-on-chronic SDH			Hyperdense acute blood mixed with chronic fluid
SDH with membranes			Membrane formations form pockets of SDH fluid

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Midline Shift = Mass Effect

- Mass effect is measured by midline shift (MLS) on CT/MRI studies
- aSDH with significant mass effect (>10mm thickness, MLS >5mm) is potentially a neurosurgical emergency

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Screening for Coagulopathy

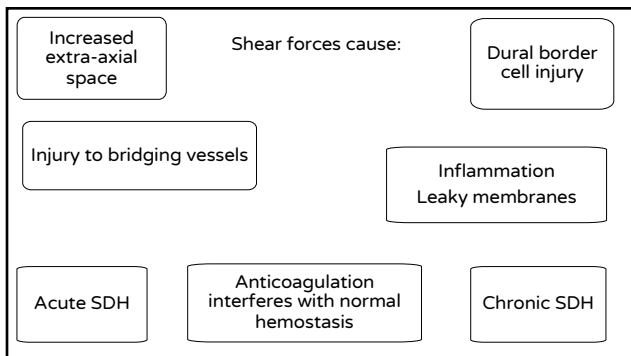
- Increased risk for SDH and recurrence: anticoagulants > antiplatelet^{1,2}
- Laboratory workup should include CBC, PT/INR and PTT³
- Reversal may be appropriate, consider risk/benefit

1. Hign SC, Rivera LA, Goshick RB, Corroly B, Casanova L. Aspirin Use and Risk of Subdural Hematoma: Updated Meta-Analysis of Randomized Trials. J Stroke Cerebrovasc Dis. Aug 2021;30(8):15931. doi:10.1097/STC.0000000000000591

2. Wang SC, Zhang QJ, Zhong H, et al. Treatment of antithrombotic drugs on the recurrence and mortality in patients with chronic subdural hematoma: A meta-analysis. Medicine (Baltimore). Jan 2019;98(1):e13972. doi:10.1097/MD.0000000000001397

3. Saha M, Wilson J, Garcia M, et al. Controversies in the Surgical Treatment of Chronic Subdural Hematoma: A Systematic Scoping Review. Diagnostics (Basel). Aug 29 2022;12(9):1610. doi:10.3390/diagnostics12091610

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Chronic SDH

- Results from injury to dural border cells¹
- Up to 24% with transient deficits²
- >75% of cSDH cases may have a normal neurologic exam³
- Recurrence after surgery is common: ~1-in-5 cases (4.9–23.6%)⁴⁻⁷
- Increased recurrence risk: anticoagulants, higher density and volume of SDH, MLS, presence of membranes⁶

1. Edgerton CJ, Singh-Godwin S, Whitfield DC, Coggerty KJA, Hutchinson PJ. Pathophysiology of chronic subdural haematoma: inflammation, angiogenesis and implications for pharmacotherapy. J Neuroinflammation. Feb 10 2021;18(1):228. doi:10.1186/s12974-021-02194-9

2. Shalton J, Zundel J, Mori J, den Hertog HMA, et al. Pathophysiology of transient neurological deficits in patients with chronic subdural hematoma: A systematic review. Acta Neurol Scand Jun 2022;145(6):646-657. doi:10.1111/acta.14522

3. Marmarou AC, Wehrli E, Hoshino A, Chang MY. Chronic subdural hematomas in the elderly: not a benign disease. J Neurology. Jan 2011;11(4):724. doi:10.1007/s00101-010-0600-0

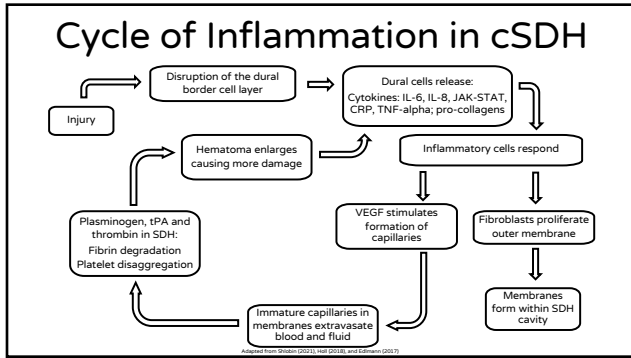
4. Kim SH, Lee SH, Kim YH, Yang SH, Song SH, Cho CH. Predictive Factors for Recurrence after Best-timed Craniotomy of Chronic Subdural Hematoma. J Korean Neurosurg Soc. Nov 2017;60(6):701-706. doi:10.3346/jksns.2017.60.6.701

5. Hammer A, Traub-Daatz A, Kersch G, Schell M, Hammer C, Dohler HA. Prediction for Recurrence of Chronic Subdural Hematoma. Turk Neurology. 2017;27(5):756-762. doi:10.5337/2016.5.756-762

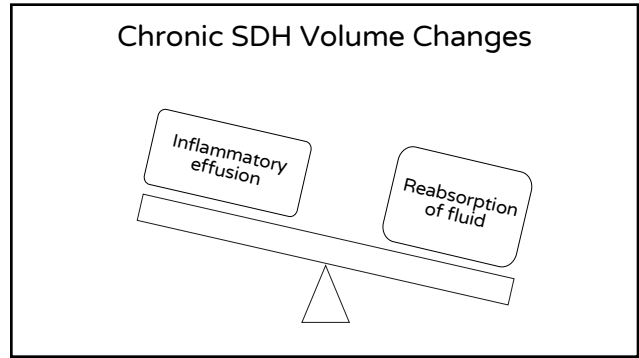
6. Sauer-Hobbes E, Kersch G, Traub-Daatz A, Kersch M, Schell M, Hammer C. Risk assessment in chronic subdural hematomas evaluated in 188 patients: A search for predicting recurrence. Clin Neuro Neurosurg. Aug 2020;195:106050. doi:10.1016/j.cnsns.2020.106050

7. Maier W, Sauer Y, Traub-Daatz A, et al. Radiological prognostic factors of chronic subdural hematomas recurrence: a systematic review and meta-analysis. Neurosurgery. Jan 2021;89(1):77-85. doi:10.1227/00006123-2020-0558-x

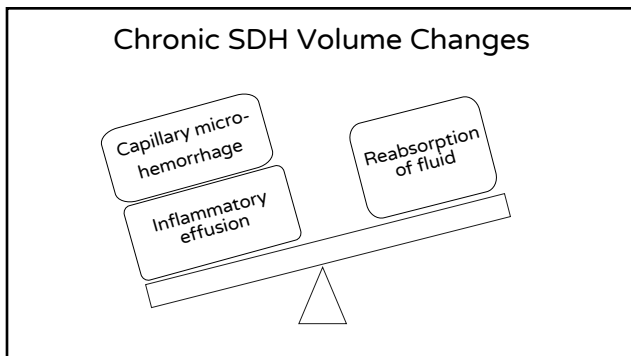
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Seizures with SDH

- Seizure associated with SDH has a pooled incidence of 7.2%¹
- Risk is not significantly reduced by antiepileptic drugs¹
- Prophylaxis is decided on case-by-case basis based on risk factors

1. Natchippan DS, Gray K. Role of prophylactic antiepileptic drugs in chronic subdural haematomas: a systematic review and meta-analysis. *Neurology Res.* Aug 2021;44(6):2068-2077. doi:10.1080/10447259.2021.1988747

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Seizures with SDH

- Highest risk:
 - Advanced age
 - Alcohol use
 - Accumulation—high volume, acute blood
 - After surgery¹
- Variable risk of developing epilepsy after SDH²

1. Natchippan DS, Gray K. Role of prophylactic antiepileptic drugs in chronic subdural haematomas: a systematic review and meta-analysis. *Neurology Res.* Aug 2021;44(6):2068-2077. doi:10.1080/10447259.2021.1988747
2. Brown DC, Cheng A, Roberts R, et al. Association of race and ethnicity to incident epilepsy, or epileptogenesis, after subdural haematomas. *Neurology* Nov 24 2020;95(21):e2390-e2396. doi:10.1212/wnl.0000000000001172

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Treatment and Prognosis of aSDH

- Order short-term follow-up head CT in ~4–6 hours
- Admit to ICU for close observation, +/- floor if minor
- Acute SDH with large MLS and low GCS has a high mortality rate that can be decreased with surgery²
- Severe deficits on presentation portend poor prognosis

1. Dandekar SK, Taylor B, Haveli A, et al. Utility of Repeat Head CT in Patients with Skull Traumatic Brain Injury Presenting with Small Isolated Foci of Peritonal Subdural Hematomas. *AJOP Am J Neurosurg* Apr 2022;84(4):567-574. doi:10.3171/ajop.assn
2. van Epen D, de Boer S, Schoneker A, et al. Mortality Reduction of Acute Surgery in Traumatic Acute Subdural Hematoma since the 19th Century: Systematic Review and Meta-Analysis with Diagnostic Effect in Surgery for Chronic Trauma? *J Neurotrauma* Aug 30 2022;doi:10.1089/neu.2022.0137
3. Brown DC, Cheng A, Roberts R, et al. Prognosis of Acute Subdural Hematomas in the Elderly: A Systematic Review. *J Neurotrauma* Feb 10 2019;36(4):517-522. doi:10.1089/neu.2018.5820

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Treatment of non-acute SDH

- Consult Neurosurgery for urgent opinion on all cases
- Rebleeding or subacute on CT, patients with signs/symptoms = more aggressive management
- Ask neurosurgery team admission and placement (ICU, floor, etc.)
- Incidental cSDH found in patients without deficits needs a clear follow-up plan for those cases not needing admission

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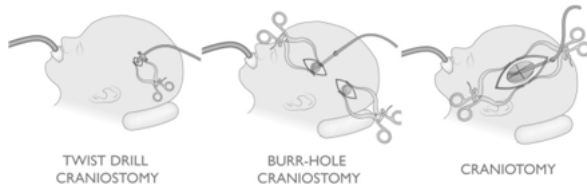
Surgery for Symptomatic cSDH

- Surgical evacuation and drain placement is standard treatment, most often by burr hole craniostomy¹
- Single or double burr hole craniostomy outcomes comparable to open craniotomy:²⁻⁴
- Open craniotomy may be preferred for cases with fibrotic membranes or substantial clot burden⁵

1. Ludwig EA, Combs DP, Gentry PG. Practice variation in the conservative and surgical treatment of chronic subdural hematomas. Clin Neurof Neurosurg Aug 2005;136:1058-60. doi:10.1054/neuro.2005.10589
2. Koppman J, Link TW, New BB, Murthy CB, Menaker AE, Kameel H. Rates of Repeated Operation for Isolated Subdural Hematoma Among Older Adults. JAMA Neurol Open Oct 5 2018;1(8):e180737. doi:10.1001/jama-neurology.2018.0737
3. Wang Y, Li W, Bai H, et al. Double Burr Hole Craniostomy in Surgical Treatment of Chronic Subdural Hematoma: A Meta-Analysis. World Neurology Nov 2015;1(11):448-454. doi:10.1052/wne.2015.07.001
4. Wang Y, Li W, Li Z, et al. Burr hole craniostomy vs. microcraniotomy of chronic subdural hematoma: a systematic review and meta-analysis. Eur Arch Neurol Psychiatry Jul 2012;262(4):483-490. doi:10.1007/s00408-012-0297-9
5. Gopalakrishnan S, Gopalakrishnan S, Choudhury S, Choudhury S, Choudhury S, Choudhury S. Microcraniotomy in Chronic Subdural Hematoma. JAMA Neurol Open Aug 2019;1(4):e190448. doi:10.1001/jama-neurology.2019.0448

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Surgical Treatments for SDH



https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6032204/figure/F1/figure/F1.html?term=SDH%20twist%20drill%20craniostomy&rank=10
1. Koppman J, Link TW, New BB, Murthy CB, Menaker AE, Kameel H. Rates of Repeated Operation for Isolated Subdural Hematoma Among Older Adults. JAMA Neurol Open Oct 5 2018;1(8):e180737. doi:10.1001/jama-neurology.2018.0737
2. Gopalakrishnan S, Gopalakrishnan S, Choudhury S, Choudhury S, Choudhury S, Choudhury S. Microcraniotomy in Chronic Subdural Hematoma: A Meta-Analysis. World Neurology Nov 2015;1(11):448-454. doi:10.1052/wne.2015.07.001
3. Wang Y, Li W, Bai H, et al. Double Burr Hole Craniostomy in Surgical Treatment of Chronic Subdural Hematoma: A Meta-Analysis. World Neurology Nov 2015;1(11):448-454. doi:10.1052/wne.2015.07.001
4. Wang Y, Li W, Li Z, et al. Burr hole craniostomy vs. microcraniotomy of chronic subdural hematoma: a systematic review and meta-analysis. Eur Arch Neurol Psychiatry Jul 2012;262(4):483-490. doi:10.1007/s00408-012-0297-9
5. Gopalakrishnan S, Gopalakrishnan S, Choudhury S, Choudhury S, Choudhury S, Choudhury S. Microcraniotomy in Chronic Subdural Hematoma. JAMA Neurol Open Aug 2019;1(4):e190448. doi:10.1001/jama-neurology.2019.0448

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Surgical Objectives for SDH

- Relieve mass effect on brain
- Allow direct or indirect control of bleeding in aSDH^{1,2}
- Washing out inflammatory mediators of cSDH
- Placing a drain to facilitate resolution

1. Mithranathan S, Srinivasan S, Murali D, et al. Acute subdural hematoma in the elderly: to operate or not to operate? A systematic review and meta-analysis of outcomes following surgery. BMJ Open Dec 3 2012;16(12):e20120176. doi:10.1136/bmjopen-2012-001766
2. Wang Y, Li W, Bai H, et al. Double Burr Hole Craniostomy in Surgical Treatment of Chronic Subdural Hematoma: A Meta-Analysis. World Neurology Nov 2015;1(11):448-454. doi:10.1052/wne.2015.07.001
3. Wang Y, Li W, Li Z, et al. Burr hole craniostomy vs. microcraniotomy of chronic subdural hematoma: a systematic review and meta-analysis. Eur Arch Neurol Psychiatry Jul 2012;262(4):483-490. doi:10.1007/s00408-012-0297-9
4. Gopalakrishnan S, Gopalakrishnan S, Choudhury S, Choudhury S, Choudhury S, Choudhury S. Microcraniotomy in Chronic Subdural Hematoma. JAMA Neurol Open Aug 2019;1(4):e190448. doi:10.1001/jama-neurology.2019.0448

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Surgical Risks for SDH

- Pneumocephalus
- Bleeding: IPH, SDH recurrence requiring reoperation¹
- Infection: subdural empyema (also a risk of untreated SDH)
 - Cranial surgical site infection ~1%, increased with reoperation²
- Seizures
- Hydrocephalus or CSF leak
- “Stroke, coma, and death” – John S. Nichols, MD, PhD
- Mortality for nontraumatic SDH at 30 days 11.6–13.8%¹

1. Koppman J, Link TW, New BB, Murthy CB, Menaker AE, Kameel H. Rates of Repeated Operation for Isolated Subdural Hematoma Among Older Adults. JAMA Neurol Open Oct 5 2018;1(8):e180737. doi:10.1001/jama-neurology.2018.0737
2. Gopalakrishnan S, Gopalakrishnan S, Choudhury S, Choudhury S, Choudhury S, Choudhury S. Microcraniotomy in Chronic Subdural Hematoma: A Meta-Analysis. World Neurology Nov 2015;1(11):448-454. doi:10.1052/wne.2015.07.001

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Twist Drill Craniostomy with Drain Insertion

- Similar outcomes vs burr holes¹
- Allows slow drainage, less acute change in ICP

1. Lu W, Bakke NA, Green RL. Chronic subdural hematoma: a systematic review and meta-analysis of surgical procedures. J Neurosurg 2014;121(6):665-673. doi:10.3171/2014.5.JNS132715

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Burr Hole Craniostomy

- Comparable to craniotomy in complications and morbidity¹⁻³
- Lower operating time and reoperation rate¹⁻³
- Similar risk of cSDH recurrence to craniotomy¹

1. Kopyov J, Lipp TW, New BJ, Murray DS, Meeker AE, Karat H. Rates of Repeated Operation for Isolated Subdural Hematoma Among Older Adults. *JAMA Netw Open*. Oct 5 2018;1(10):e183737. doi:10.1001/jamanetworkopen.2018.3737

2. Wei Y, Wu D, Sun J, et al. Burr Hole Craniostomy in Surgical Treatment of Chronic Subdural Hematoma: A Meta-Analysis. *World Neurology*. Nov 2018;13(11):4349-4354. doi:10.4236/wjn.2018.131134

3. Wang Y, Wu D, Sun J, et al. Burr Hole Craniostomy vs. Craniotomy in the Treatment of Chronic Subdural Hematoma: A Systematic Review and Meta-analysis. *Eur Arch Med Pharmacol*. Oct 14 2022;292(4):489-499. doi:10.2455/eurarch.202207.2024

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Open Craniotomy

- Allows removal of clot and direct control of active bleeding
- Extensive irrigation to wash out inflammatory mediators
- Removal of active membranes / opening of loculated cavities

Sahawneh R, Marikakis N, Tran P, Rosoff JL, Chen JW. Membranectomy in Chronic Subdural Hematoma. *Meta-Analysis*. *World Neurology*. Aug 2017;7(8):418-429. doi:10.1006/wneu.2017.08.030

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Subdural and Subgaleal Drainage

- Placement of a drain significantly decreases risk of recurrence^{1,2}
- Studies have evaluated various types and locations for drain placement
- Drainage is continued for 24–48 hours³
 - no advantage to longer duration
 - ↑ infection and hospital stay
- Antibiotic prophylaxis may be continued until drain is DC'd

1. Hwang J, Anzol M, Nelson M, et al. Management of Chronic Subdural Hematoma: A Systematic Review and Component Network Meta-analysis of 455 Studies With 123 445 Cases. *Neurosurgery*. Sep 28 2022;91(3):E1277-1279. doi:10.1227/NEU.0000000000002214

2. Kim H, Lee J, Lee J, et al. Comparison of Subgaleal or Subdural Drainage with Subdural Drainage on the Duration of Chronic Subdural Hematoma: A Meta-Analysis. *World Neurology*. Mar 2021;12(3):47-56. doi:10.4236/wjn.2021.123005

3. Wang Y, Wu D, Sun J, et al. Burr Hole Craniostomy vs. Craniotomy in the Treatment of Chronic Subdural Hematoma: A Systematic Review and Meta-analysis. *Eur Arch Med Pharmacol*. Oct 14 2022;292(4):489-499. doi:10.2455/eurarch.202207.2024

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Emerging Treatments for cSDH

Non-operative treatments investigated (off-label*) for use as adjunct to or alternative to surgery:

- Dexamethasone with or without atorvastatin
- Tranexamic acid (TXA)
- Middle meningeal artery embolization (MMAE)

*SDH is not an FDA approved indication

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Tranexamic Acid

- Used off-label for treatment of acute hemorrhage in trauma and high-loss surgeries
- Decreases volume of SDH in studies given PO after burr hole evacuation for cSDH
- Mixed results on reduction in recurrence rate
- Randomized placebo-controlled trials pending

Yamada T, Nelson Y. Prospective Study on the Efficacy of Daily Administered Tranexamic Acid and Sorafenib for the Prevention of Recurrence After Chronic Subdural Hematoma Burr Hole Surgery. *World Neurology*. Feb 2020;11(4):449-453. doi:10.4236/wjn.2020.114049

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Middle Meningeal Artery Embolization

- Endovascular procedure to occlude blood flow to outer membranes supplied by middle meningeal artery
- Leads to slow resolution of cSDH
- Composite cSDH recurrence rate from meta-analysis of 3.6%
- Lower complication and recurrence rates compared to craniotomy

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Key Points

- Patients at risk for SDH are over 65, on anticoagulants, and may have a history of head injury
- Head CT is ideal for primary and follow-up studies; MRI for differential diagnosis
- Evaluate bleeding risk with a careful review of medications and laboratory studies

Original image by T. Scoville

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Key Points

- Hold anticoagulants pending neurosurgery consultation for risk/benefit evaluation
- Consider seizure prophylaxis for high-risk individuals (5As): advanced age, alcohol use, aggressive (MLS/acute bleeding), after surgery, African ethnicity
- Craniotomy with drainage is the standard treatment; potential alternatives are emerging for select cases

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