

Comparative Impacts of Subdural Hematoma and Diffuse Axonal Injury on Brain Function

Aleemah Ayomide, ALABI-LAWAL^{1*}

¹Biomedical Science Department, Charles Darwin University, Australia

*Correspondence Author: Email: aleemah.alabi-lawal@students.cdu.edu.au

APA Citation and Referencing: ALABI-LAWAL, A.A. (2026). Comparative Impacts of Subdural Hematoma and Diffuse Axonal Injury on Brain Function. *JENER Journal of Empirical and Non-Empirical Research*, 1(3), 185-191

ARTICLE INFORMATION	ABSTRACT
<p>Article history: Published on 15th Jan 2026</p> <p>Keywords: Brain Diffuse Axonal Injury Subdural Hematoma</p>	<p>Traumatic brain injury (TBI) is still a major cause of disability and death around the world, often leading to serious problems with the brain and thinking skills. Subdural Hematoma (SDH) and Diffuse Axonal Injury (DAI) are some of the most damaging types of TBI. SDH causes pressure on specific parts of the brain, which can lead to reduced blood flow, swelling, and problems with nerve cells. DAI, on the other hand, is caused by widespread damage to nerve fibres in the brain's white matter. Both SDH and DAI can seriously affect movement and thinking skills like attention, memory, and the ability to plan and make decisions. This paper looks at how SDH and DAI affect the body, how they disrupt motor and cognitive networks, and what this means for patient care. A better understanding of these issues is key to improving how we predict outcomes, choose treatments, and rehabilitate people with TBI.</p>

1. Introduction

Traumatic Brain Injury (TBI) happens when an outside force hurts the brain. Things like hits, crashes, or sudden movements can cause it. Every year, about 69 million people across the world get a TBI. This can lower their quality of life, create health care issues, and reduce how much they can work (Maas et al., 2022). TBIs are generally grouped into two types. Focal injuries affect one specific area in the brain. Diffuse injuries disrupt brain cells across larger networks (Graham et al., 2020). Subdural Hematoma (SDH) and Diffuse Axonal Injury (DAI) are two important types in clinics. SDH is a focal injury where blood gathers between layers covering the brain, causing pressure. DAI is a diffuse injury that involves the stretching plus tearing of nerve fibres, mostly in the brain's white matter, brainstem, and connections between various parts of the brain (Mesfin, 2023). Both SDH and DAI can lead to serious long-lasting problems with movement and mental abilities. Motor issues come from harm to brain areas that control movement. Cognitive problems come from broken links in brain networks related to thinking and emotions. It is important to be aware that problems such as lack of blood flow, inflammation, and stress can worsen the initial injury and slow down recovery time (Weigel et al., 2022). This paper looks at how SDH and DAI affect the brain and how these effects differ or overlap. It also talks about rehab and how the brain can adapt to heal after these injuries. (Maas et al., 2022; Graham et al., 2020; Mesfin, 2023; Weigel et al., 2022).

1.1 Pathophysiology of Subdural Hematoma: What Happens and How It Causes Harm

A Subdural Hematoma (SDH) happens when veins between the brain's surface and the outer covering break. This lets the blood pool in the space between them. SDHs are grouped as acute, subacute, or chronic, based on how quickly the bleeding occurs and what the patient looks like (Weigel et al., 2022).

- I. **Mechanical Compression and Intracranial Pressure (ICP):** As the blood clot grows, it presses on the brain, squishing and moving brain tissue out of place. This pressure inside the skull cuts off blood flow to the brain, causing a lack of oxygen (van Essen et al., 2022). This messes with energy production in brain cells, causing them to die.
- II. **Neuroinflammation and Secondary Injury:** After the first bleed, stuff from the broken-down blood, like hemoglobin and iron, causes stress and activates brain immune cells. This starts the release of chemicals that cause swelling and damage the protective barrier around the brain (Wang et al., 2021; Dubinski et al., 2022). This swelling makes the damage worse killing more brain cells than just those affected by the initial bleed. This inflammation can stick around for weeks or months, slowing down healing.
- III. **Angiogenic and Glial Response:** The pressure and chemicals also wake up certain brain cells, which then try to grow new blood vessels and form scar tissue. While new vessel can bring back blood flow, weird vessel growth can make swelling or repeat bleeding worse (Weigel et al., 2022). Other brain cells react to protect the brain at first, but later, this reaction can stop the brain from rewriting itself and adapting. (Weigel et al., 2022; Dubinski et al., 2022).

1.2 Impact of Subdural Hematoma on Motor Control and Cognition

The effects of SDH on neurological function depend heavily on the location and size of the hematoma.

- I. **Motor Impairments:** If an SDH presses on the parts of the brain that controls movement, like the frontal motor cortex, internal capsule, or parietal motor association areas, you might get weakness on one side of your body, wobbly muscles, and have trouble moving smoothly. If it's on the side of the brain that controls language, it can cause weakness on the opposite side of your body. SDHs on both sides can make you generally weak or make it hard to start moving (Zampieri et al., 2023). Also, if the pressure inside your head goes up because of the SDH, that can mess with the signals that tell your muscles what to do, making it even harder to move and stay balanced. (van Essen et al., 2022).

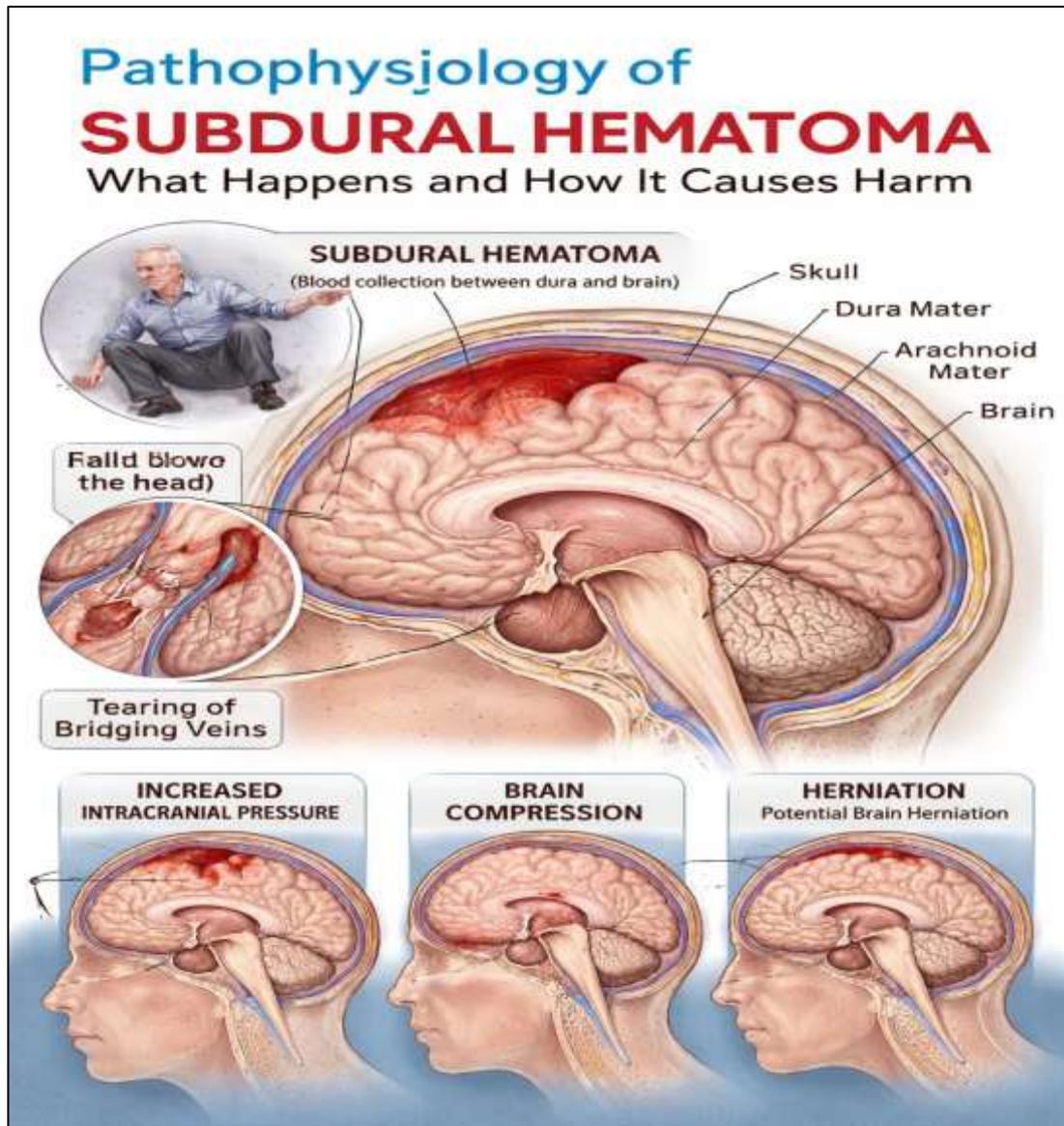


Fig 1: Diagram Created with ChatGPT (GPT-40-mini) by Open AI, (12th December, 2025)

- II. **Cognitive Deficits:** When a SDH presses on the front or side of the brain, it can mess with the ability to make good choices, pay attention, and remember things. Older folks with long-term SDHs often think slowly, do not care about stuff, and cannot plan well (Blaauw et al., 2021) It is like having problems with the front part of your brain, which oversees all that higher-level thinking. Also, if the brain does not get enough blood or gets inflamed for too long because of the SDHs, it can mess with the connections between various parts of the brain. That is why even small SDHs can sometimes cause people to have a lot of trouble thinking. Brain scans show that people who still have SDHs have weaker links between the front of their brain and the sides, which are important for paying attention and seeing things in space (Zhou et al., 2022). (Blaauw et al., 2023; Zampieri et al., 2023; Zhou et al., 2022).
- III. **Long-Term Outcomes:** Getting Surgery quickly to remove SDH, controlling the pressure inside the head, and making sure the brain gets enough oxygen that can help recovery. But if the SDH presses on the brain for too long or you do not get help fast enough, it can cause lasting, like the brain getting thinner, brain cells dying, and changes in how you act. Even months after the brain seems to have healed, people might still have trouble making decisions, move slowly, and forget things (van Essen et al., 2022; Blaauw et al., 2023).

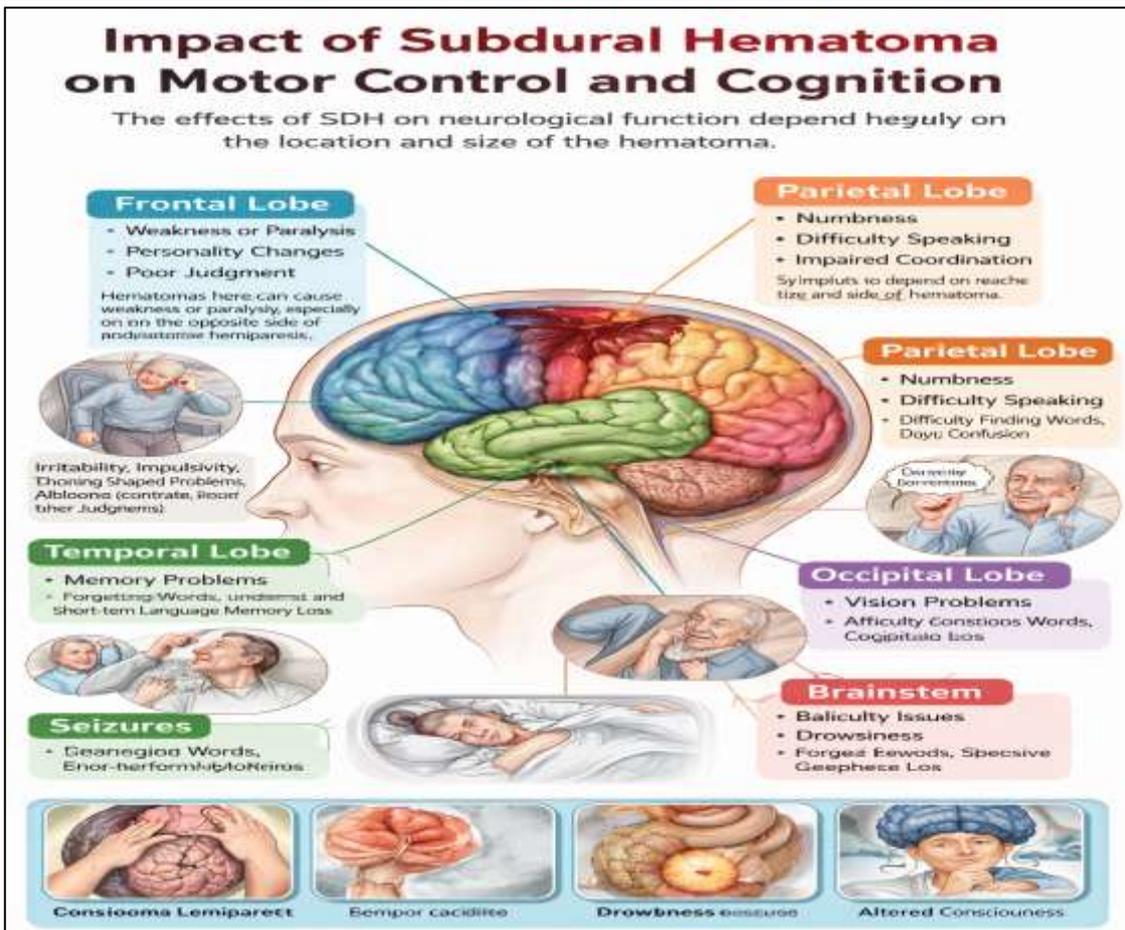


Fig 2: Diagram Created with ChatGPT (GPT-4o-mini) by Open AI, (15th December, 2025)

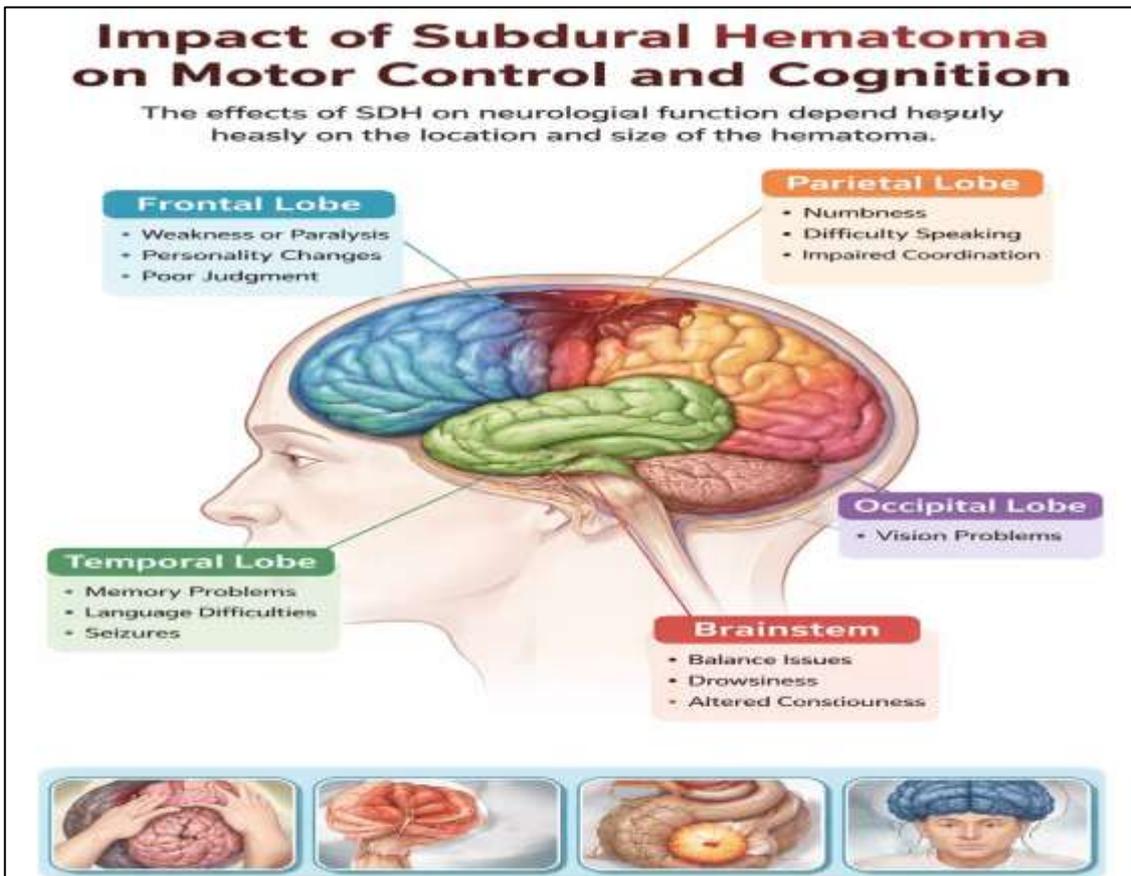


Fig 3: Diagram Created with ChatGPT (GPT-4o-mini) by Open AI, (12th December, 2025)

1.3 How Diffuse Axonal Injury (DAI) Works

Diffuse Axonal injury (DAI) is important when it comes to traumatic brain injury (TBI). It usually happens when the head gets whipped around fast, like in car accidents, falls, or if you're violently shaken (Mesfin, 2023). Unlike bleeds that squash on e part of the brain, DAI messes up the tiny fibres (axons) all over the place. That's why it can be so bad, often leading to long comas, a kind of vegetative state, and lasting brain problems.

- I. Mechanical Axonal Stretching and Cytoskeletal Disruption: When the brain gets twisted fast inside the skull, these fibres get strained, mainly where the grey and white matter meet because the tissue is different there. This messes with the fibre's outer layer, scrambles its inside, and makes it swell up. Eventually, it can snap completely (Graham et al.,2020). Soon after, you get these little blobs (axonal bulbs) full of gunk like amyloid precurs or protein (APP), showing where things got cut off and are starting to break down (Krieg et al., 2023; Graham et al., 2020).
- II. Secondary Biochemical Cascades: After the first hit, a bunch of serious stuff happens. Calcium levels inside cells goes up, which kicks off a chain reaction that breaks down the cell's structure and screws with its energy supply (Mesfin 2023; Grassi et al., 2021). On top of that, too much glutamate (a brain chemical) floods the area, making things even worse by causing stress and draining energy. Then, the immune system jumps in, with brain cells called microglia going into overdrive, which can cause even more axon damage and strip away insulation, spreading the damage beyond the first spot (Mesfin,2023; Ge et al., 2022).
- III. Disruption of White-Matter Networks: DAI hits important pathways in the brain, like the corpus callosum, internal capsule, and brainstem (Zhou et al., 2022; Jolly et al., 2021). When these areas get damaged, various parts of the brain cannot talk to each other. That is why even if the brain looks okay on scans, people can still have major problems with things like sensing stuff, moving around, and making decisions. It is like the brain's wires got cut (Graham et al., 2020; Jolly et al., 2021).

1.4 Impact of DAI on Motor Control

DAI messes with how the brain controls muscles because it damages the paths that carry signals for movement, the links of your cerebellum, and how your brain puts sensory information together with movement. How bad your motor skills get depends on how bad and where the damage to the nerve fibres is.

- I. Corticospinal Tract Involvement: DAI often hits the internal capsule and brainstem hard. That is where the corticospinal fibres come together. If these spots get damaged, it screws up your ability to move on purpose, causing stiffness, weakness, or not being able to move at all. if the damage goes into the midbrain or pons, it can cause weird postures, which are big signs of serious nerve fibre damage. (Jolly et al., 2021; Zampieri et al., 2023).
- II. Cerebellar and Basal Ganglia Pathways: The damage can also mess with the cerebellar peduncles and basal ganglia routes, leading to problems with coordination peduncles and basal ganglia routes, leading to problems with coordination like ataxia, tremors and dysmetria. Research using DTI has found less fractional anisotropy in the cerebellum in DAI patients, which is linked to balance and walking issues. (Fagan et al., 2024; Grassi et al., 2021)
- III. Motor planning and Execution: Motor problems from DAI are not just about weak muscles. They also include problems with planning, ordering, and carrying out movements. This happens because the premotor, supplementary motor, and prefrontal cortices are not talking to each other right. These problems can show up as apraxia or trouble starting movements on your own, even if you still have strength. (Anderson et al., 2023; Grassi et al., 2021).

1.5 How DAI Affects Thinking Skills

Since DAI messes with the brain's white matter, which is like its wiring, it can cause a bunch of different thinking issues. These can include trouble with attention, memory planning, and how fast you can think - all things that rely on various parts of the brain talking to each other.

- I. Executive Dysfunction and Frontal Lobe Disconnection: The front parts of the brain are easily damaged by DAI. When the connection between the front part of the brain and deeper brain areas is disrupted, it makes it hard to set goals, solve problems and control impulses. People often struggle to do more than one thing at time, makes choices and pay attention, which makes everyday life tough. (Ponsford et al., 2023; Chen et al., 2023).
- II. Memory and Learning Impairments: When DAI damages the nerve fibres connected to memory centres, it messes with how information moves around the brain. This can cause trouble making new memories and remembering old ones. A study showed that people with DAI had smaller memory centres and weaker which led to worse performance on memory tests. (Chen et al., 2023; Anderson et al., 2023).
- III. Reduced Processing Speed and Attention: Disruptions in other brain areas can make thinking slower and hard to focus on more than one thing at a time. Brain scans show that even mild DAI can reduce activity in brain networks needed for attention, leading to tiredness and reduced stamina. (Ponsford et al., 2023; Grassi et al., 2021).
- IV. Emotional and Behavioural Dysregulation: Aside, movement and thinking issues, DAI can also mess with mood and behaviour. It can disrupt brain circuits that control emotions, leading to mood swings, sadness, and grumpiness. These Changes can make it hard to get back into life and enjoy life in general. (Mesfin,2023; Ponsford et al., 2023).

Table I: Comparative Analysis SDH Vs DAI

Feature	Subdural Hematoma (SDH)	Diffuse Axonal Injury
Nature of Injury.	Focal due to Venous bleeding between dura and arachnoid.	Diffuse, due to shearing/stretching of axons.
Primary	Compression and raised intracranial pressure.	Axonal disconnection and white-matter disruption.

Mechanism		
Main Affected Regions	Cortical surfaces, especially frontal/parietal lobes	Corpus callosum, brainstem, internal capsule, white matter
Motor Impact	Hemiparesis, weakness, impaired coordination due to cortical compression	Paralysis, spasticity, ataxia from disrupted motor tracts
Cognitive Impact	Executive dysfunction, slowed processing from cortical ischemia	Memory, attention, and executive dysfunction from network disconnection
Prognosis	Often favourable with surgical intervention if detected early	Variable; often worse due to diffuse and irreversible axonal loss
Imaging Finding	Hyper dense crescent- shaped lesion on CT	Punctuate lesions on MRI (esp. DTI), often missed on CT

SDH squishes things in one spot, messing up specific brain functions, But DAI disconnects the whole brain network, causing more general problems with thinking and movement. These two injuries can happen together. SDH can make DAI worse, and DAI can slow down healing after you fix the squishing from SDH. (Weigel et al., 2022; Mesfin, 2023).

1.6 Neuroplasticity and Recovery Mechanisms

Getting better after brain injuries like Subdural Hematoma (SDH) and Diffuse Axonal Injury (DAI) depends a lot on how well the brain can rewire itself. This means it can rearrange how it cells talk to each other, make stronger links between cells that survived, and even totally make pathways. This rewriting thing, called neuroplasticity, is key for getting back things like moving and thinking after a brain Injury (TBI). (Zotey, 2023).

- I. Structural and Functional Reorganization: When parts of the brain get squeezed or axons get damaged, the parts that are still okay can take over the jobs of the hurt areas. This happens as brain cells make new offshoots, regrow, and branch out to make pathways (Zotey,2023). When someone has SDH, taking the pressure off the brain helps the areas around the injury wake up and start rewriting things. With DAI, the white matter survives might work harder to let both sides of the brain talk to each other, which helps make up for the damaged areas (Anderson et al., 2023). Brain Scans(fMRI) show that when people with DAI try to move, the motor areas on the opposite side of the brain light up more. This means the brain is remapping how it controls problems like stiffness or weird movements if it isn't guided by the right kind of treatment. (Zotey,2023; Anderson et al., 2023).
- II. Cellular and Molecular Plasticity: Inside the cells, things like LPT and stuff that helps cell grow (like BDNF) help make the connections between brain cells stronger. How well this works depends on how intense the rehab is, the environment a person is in, and if they are taking any medicine (Shin et al., 2022; Zotey, 2023). Medicine that fights swelling and protect the brain, like minocycline or N-acetyecysteine, have been shown to help brain cells survive and rebuild the coating around nerves after DAI (Ge et al., 2022).

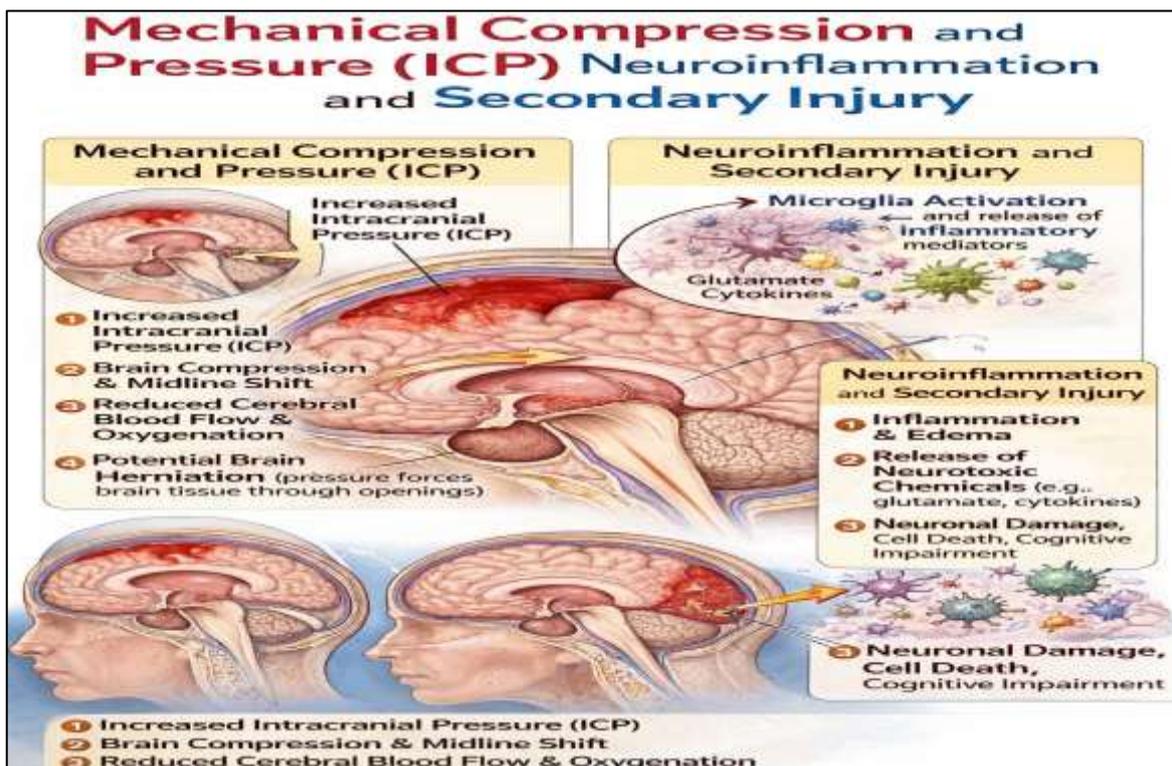


Fig 4: Diagram Created with ChatGPT (GPT-40-mini) by Open AI, (13th December, 2025)

1.7 Rehabilitation and Clinical Management

Dealing with SDH and DAI is tough, and getting better needs a team effort such as Surgeons, rehab experts, doctors who prescribe meds, and therapists.

I. Acute Management

a) Subdural Hematoma: If you have an acute SDH, they usually need to do surgery to let the pressure off your brain-either with small holes or cutting a bigger opening (van Essen et al., 2022; Shafique et al., 2024). Getting blood flowing again ASAP is super important to keep things from getting worse. After surgery, they will watch your brain pressure, make sure you do not have seizures, and keep your electrolytes in check (van Essen et al., 2022).

b) Diffuse Axonal Injury: With DAI, there is no surgery to do since there is no specific spot to fix. Instead, things are kept stable. The goal is to stop more damage by making sure you are getting enough oxygen, keeping your blood pressure steady, and watching what is going on inside your skull (Mesfin,2023). There are studies being done with drugs that might protect the brain by messing with things like Inflammation, but those are still experimental (Kreig et al.,2023; Mesfin, 2023).

II. Subacute and Long-Term Rehabilitation Physical and Occupational Therapy

a) Physical and Occupational Therapy: As soon as you are stable, rehab kicks in. Doing drills and exercises helps your brain rewire itself and strengthen the pathways that control movement (Zotey,2023; Anderson et al., 2023). For DAI patients who are stiff or have trouble with balance, robots and electrical stimulation can get them moving better and walking again (Fagan et al., 2024).

b) Cognitive Rehabilitation: This helps with things like attention, memory, and making decisions. Stuff like goal setting and learning how to think about your thinking can help people solve problems and adjust after DAI (Ponsford et al.,2023). Also, computer games and virtual reality can make rehab more interesting and help the brain heal. (Ponsford et al., 2023).

c) Speech and Language Therapy: If SDH or DAI messes with part of your brain that handles language, you could have trouble speaking or understanding. Speech therapy works on things like sounds, meanings, and rhythm to help rebuild those communication pathways (Anderson et al., 2023).

d) Psychological and Social Support: Since DAI can mess with your emotions, therapy, and drugs for things like depression or anxiety can help. it is also important for families to learn about what is going on and get support because personality changes can be hard on relationships (Ponsford et al., 2023; Mesfin,2023).

1.8 Emerging Approaches in Recovery Enhancement

Some recent studies look at using the brain and biotech to help people get back to doing what they could do before, much quicker than before.

I. Non-Invasive Brain Stimulation (NIBS): Things like TMS and tDCS seem like they could make the brain injury (Shin et al., 2022). For People with severe brain injuries, these things might help the two sides of the brain talk to each other again, so they can pay attention better or move better.

II. Stem-cell and Regenerative Therapies: The idea here is to use stem cells to replace brain cells that are gone and help the brain grow back. Mesenchymal stem cells (MSCs) make stuff that helps the brain heal and reduces swelling, which could help fix the white stuff in the brain (Ge et al., 2022). Some early tests show that people with long-term brain injuries get better with this treatment, but more tests need to be done. (Ge et al.,2022)

III. Neuroimaging-Guided Rehabilitation: Fancy brain scans, like DTI and resting -state fMRI, let doctors see how the white stuff in the brain is healing. They can then use this info to make a rehab plan that is just for that person and their specific brain injury (Jolly et al., 2021; Zhou et al., 2022). Using brain scans to guide rehab is looking like the way things will be done in the future.

1.9 Prognosis and Outcomes

Recovery from SDH and DAI depends on a few things: how bad the is, how old you are, when you get help, and how rehab you do.

SDH: If the blood is gotten out fast and the pressure in the head is kept down, things usually go well. But if they wait for too long or the bleeding comes back, it can cause thinking problems and trouble moving around later. (van Essen et al., 2022; Blaauw et al., 2023).

DAI: It is harder to say what will happen with this one. Because the damage is spread out, people often have long-term problems. If it is not too bad, the brain can sometimes rewire itself and get better. But if it is really bad, people might end up in a coma or with dementia later (Mesfin,2023; Graham et al., 2020).

Good rehab programs can really help people be more independent and have a better life. Still, even with rehab, some small thinking problems can stick around for years.

1.10 Conclusion

To sum things up, Subdural Hematoma (SDH) and Diffuse Axonal Injury (DAI) are two different brain injuries that often happen together after a traumatic brain injury. SDH squishes parts of the brain, leading to problems like reduced blood flow and thinking issues. DAI, on the other hand, messes up the brain's wiring, which affects movement and thought.

Both SDH and DAI can cause trouble with movement (like weakness or poor coordination) and thinking because they hurt important brain areas. The ongoing inflammation after these injuries makes things worse and slows down healing. But the brain can adapt, and with the help of rehab and new treatments, people can recover a lot of their abilities.

It is super Important to diagnose these injuries early and provide the right care, like surgery or support, along with rehab. More research into treatments that protect the brain, stem-cell therapy, and rehab guided by brain scans will really help people get better and live fuller lives after TBI, especially those dealing with the long-term effects of SDH and DAI. (Mass et al., 2022; Mesfin,2023; Zotey,2023).

References

- [1] Anderson, J. F., et al. (2023). The relationship between cognition and white matter tract microstructure following traumatic brain injury. *Frontiers in Neurology*, 14, 1278908. <https://doi.org/10.3389/fneur.2023.1278908>
- [2] Blaauw, J., et al. (2023). The cognitive status of chronic subdural hematoma patients after treatment: an exploratory study. *Journal of Clinical Neuroscience*, 102, 55–62. <https://doi.org/10.1016/j.jocn.2023.01.010>
- [3] Dubinski, D., et al. (2022). Recurrence of chronic subdural hematoma and inflammatory mechanisms — recent clinical observations. *European Neurological Journal*, 2022. (review) <https://www.frontiersin.org/>
- [4] Fagan, M. M., Scheulin, K. M., Sneed, S. E., Sun, W., Welch, C. B., Cheek, S. R., Kaiser, E. E., Zhao, Q., Duberstein, K. J., & West, F. D. (2024). White Matter Integrity and Motor Function Disruption Due to Traumatic Brain Injury in Piglets: Impacts on Motor-Related Brain Fibres. *Brain sciences*, 14(3), 247. <https://doi.org/10.3390/brainsci14030247>
- [5] Ge, X., et al. (2022). Chronic inflammatory responses and neurodegeneration following brain injury: review and therapeutic targets. *Frontiers in Cellular Neuroscience*, 16, 930697. <https://doi.org/10.3389/fncel.2022.930697>
- [6] Graham, D. I., et al. (2020). Diffuse axonal injury in the pathogenesis of traumatic brain injury. *Brain Pathology*, 30(1), 39–56. <https://doi.org/10.1111/bpa.12780>
- [7] Grassi, D. C., et al. (2021). Dynamic changes in white matter following traumatic brain injury: longitudinal DTI study. *Journal of Neurotrauma*, 38(4), 495–508. <https://doi.org/10.1089/neu.2020.7413>
- [8] Jolly, A. E., et al. (2021). Detecting axonal injury in individual patients after traumatic brain injury. *Brain*, 144(1), 92–105. <https://doi.org/10.1093/brain/awaa336>
- [9] Krieg, J. L., et al. (2023). Identifying the phenotypes of diffuse axonal injury following traumatic brain injury. *Brain Sciences*, 13(11), 1607. <https://doi.org/10.3390/brainsci13111607>
- [10] Maas, A. I. R., Menon, D. K., Adelson, P. D., Andelic, N., Bell, M. J., Belli, A., Bragge, P., Brazinova, A., Büki, A., Chesnut, R. M., Citerio, G., Coburn, M., Cooper, D. J., Crowder, A. T., Czeiter, E., Czosnyka, M., Diaz-Arrastia, R., Dreier, J. P., Duhaime, A. C., Ercole, A., ... InTBIR Participants and Investigators (2017). Traumatic brain injury: integrated approaches to improve prevention, clinical care, and research. *The Lancet. Neurology*, 16(12), 987–1048. [https://doi.org/10.1016/S1474-4422\(17\)30371-X](https://doi.org/10.1016/S1474-4422(17)30371-X)
- [11] Mesfin, F. B. (2023). Diffuse axonal injury. In *StatPearls* [Internet]. Treasure Island (FL): StatPearls Publishing. (2023). <https://www.ncbi.nlm.nih.gov/books/NBK448102/>
- [12] Ponsford, J., et al. (2023). INCOG 2.0 guidelines for cognitive rehabilitation following traumatic brain injury. *Journal of Head Trauma Rehabilitation*, 38(1), 7–23. <https://doi.org/10.1097/HTR.0000000000000838>
- [13] Shafique, M. A., et al. (2024). Surgical strategies in acute subdural hematoma: meta-analysis of decompressive craniectomy vs craniotomy. *Acta Neurochirurgica*, 166, 1–14. <https://doi.org/10.1007/s00701-024-06013-1>
- [14] van Essen, T. A., et al. (2022). Surgery versus conservative treatment for traumatic acute subdural haematoma: a prospective, multicentre, observational, comparative effectiveness study. *Lancet Neurology*, 21(7), 620–631. [https://doi.org/10.1016/S1474-4422\(22\)00166-1](https://doi.org/10.1016/S1474-4422(22)00166-1)
- [15] Weigel, R., Schilling, L., & Krauss, J. K. (2022). The pathophysiology of chronic subdural hematoma revisited: emphasis on aging processes as key factor. *Geroscience*, 44, 1353–1371. <https://doi.org/10.1007/s11357-022-00570-y>
- [16] Zampieri, C., et al. (2023). Associations between white matter integrity and postural control in adults with traumatic brain injury. *PLoS ONE*, 18(2): e0288727. <https://doi.org/10.1371/journal.pone.0288727>
- [17] Zhou, Y., et al. (2022). Resting-state fMRI studies of functional connectivity alterations after brain injury: implications for SDH and DAI. *Frontiers / Human Brain Mapping—related studies*, 2022. (Representative functional connectivity literature)
- [18] Zotey, V. (2023). Adaptive neuroplasticity in brain injury recovery. *Neural Regeneration Research*, 18, 1-18. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10598326/>