

Application of Artificial Intelligence in Early Detection of Epidural Hematoma

Abdullah Asy Syifa¹, Qurraru Ainy², Ahmad Wirawan³

Universitas Muhammadiyah Makassar

abdullahasyifa@med.unismuh.ac.id

Keywords

Artificial Intelligence,
Early Detection, Epidural
Hematoma, Machine
Learning, Neuroimaging,
Traumatic Brain Injury

Abstract

Head injury is an emergency condition that is still the leading cause of death. Manifestations of head injury may be accompanied by intracranial hemorrhage, one of which is epidural hemorrhage or epidural hematoma (EDH). This study aims to explore the potential application of artificial intelligence in the early detection of epidural hematoma with the main objective of improving early diagnosis and management of this condition. This paper uses a literature review study method derived from the analysis of various references. The references used have inclusion criteria in the form of full text type, related to the topic of discussion using "Artificial Intelligence", "Deep learning", and "epidural hematoma". The result of this study is that EWS finds the presence of EDH in two or more images from a set of CT-Scans, the system will send an email to the medical practitioner with an attachment of images showing EDH for immediate action. In previous tests, the system successfully diagnosed 13 out of 27 patients with EDH, with 85% of the diagnoses having a high level of importance. This shows that the EWS has the potential to improve early detection and management of EDH cases, as well as provide medical practitioners with important information for appropriate action.

Corresponding Author: Abdullah Asy Syifa
Email: abdullahasyifa@med.unismuh.ac.id



INTRODUCTION

Head injury is an emergency condition that causes the most deaths with a relatively high incidence rate. Although epidemiological data in Indonesia is not yet available, head injuries have a severe impact on the country's health. For example, in England, 1.4 million people suffer head injuries every year, with 150,000 sufferers registered in hospitals. Head injuries can cause temporary or permanent disturbances in neurological, physical, cognitive and psychosocial functions. The manifestation is usually accompanied by intracranial bleeding due to rupture of blood vessels in the brain, one of which is Epidural bleeding or Epidural Hematoma (Ansar et al., 2021; Rudyanto et al., 2023; Awaloei et al., 2016; Rawis et al., 2016; Astuti et al., 2016; Siahaya et al., 2020).

Epidural Hematoma (EDH) is a collection of blood found in the epidural area between the internal tabula and the dura mater layer. Imaging with Computerized Tomography Scanning (CT-Scan) is currently the standard diagnostic modality because it can show all brain tissue accurately, the location of the lesion, and its extent. However, it takes quite a long time for patients with head injuries to be diagnosed, whether there is EDH or other intracranial bleeding, considering the service algorithm in hospitals and not all hospitals provide radiological examinations, so a referral needs to be made first. In response to this, technology is required that can detect intracranial bleeding in patients with head injuries, especially those accompanied by EDH (Manarisip et al., 2014; Darmayanti & Armaijn, 2020; Yunus et al., 2020).

Nowadays, technology has developed rapidly following the development of science and research, which is continuously carried out so that human life is increasingly integrated with technology, which continues to grow, as well as in the world of medicine; medical technology continues to follow technological developments so that it can provide the best

health services. Research on health services integrated with technology in the medical field is developing rapidly, especially regarding artificial intelligence (AI) (Azimah & Rizky Nova Wardani, 2022). AI itself is a technology designed to have intelligence that can be compared to human intelligence by imitating human cognitive functions in problem-solving, as well as learning, thinking and behaving like humans (Brynjolfsson et al., 2018; Jiang et al., 2021; Malik et al., 2019; Malik et al., 2019; Pedersen et al., 2018).

Technology integrated with AI has been developed in medical imaging to achieve effectiveness and efficiency in radiological examinations. Most AI applications in the imaging field can be used in emergencies for effective and efficient interpretation and diagnosis. Considering the development of medical technology integrated with AI, especially in imaging with the high number of head injury cases with EDH as a manifestation, technology combined with AI is needed with specificity for early detection of EDH in patients with head injuries (Hosny et al., 2018; Katzman et al., 2023; Mello-Thoms & Mello, 2023).

Research into the application of artificial intelligence in the early detection of epidural hematoma has significant potential benefits in the medical field. With the ability to detect the symptoms of epidural hematoma quickly and accurately, this research can assist in reducing delays in the delivery of critical care, improving patient safety, and optimizing the use of medical resources. In addition, the results of this study can support the development of better decision support systems, improve the prediction of patient outcomes, and open the door for more innovative follow-up research in the field of epidural hematoma detection and management.

This study aims to explore the potential application of artificial intelligence in the early detection of epidural hematoma with the primary aim of improving the early diagnosis and management of this condition. The hypothesis is that the use of artificial intelligence algorithms trained with relevant medical data can improve the ability to detect signs of epidural hematoma more quickly and accurately than traditional methods. Thus, it is hoped that artificial intelligence systems can reduce delays in critical care, improve patient outcomes, and assist in the management of medical resources more efficiently. In addition, it is assumed that the results of this study will pave the way for the development of better decision support systems and continued innovation in the field of epidural hematoma detection and management.

RESEARCH METHODS

The writing of this literature review uses a literature review study method derived from the analysis of various references both nationally and internationally. The references used in this literature review have inclusion criteria in the form of full text types, related to the topic of discussion using "Artificial Intelligence", "Deep learning", and "epidural hematoma" as keywords in several databases, namely Pubmed, Google Scholar, ScienceDirect, and ResearchGate, and confirmed to have been published in the last ten years.

RESULTS AND DISCUSSION

Application of Artificial Intelligence in Neuroradiology

One example of AI widely applied today is machine learning, which is divided into supervised and unsupervised machine learning. This case will discuss supervised machine learning. Some data can help train the machine's algorithm in supervised machine learning. For example, a machine that has been integrated with data related to nerve CT-Scan images, which have been grouped into different groups by neuroradiologists (with or without bleeding), will help the machine provide more accurate predictions (LeCun et al., 2015; Mwangi et al., 2014; Hassabis et al., 2017).

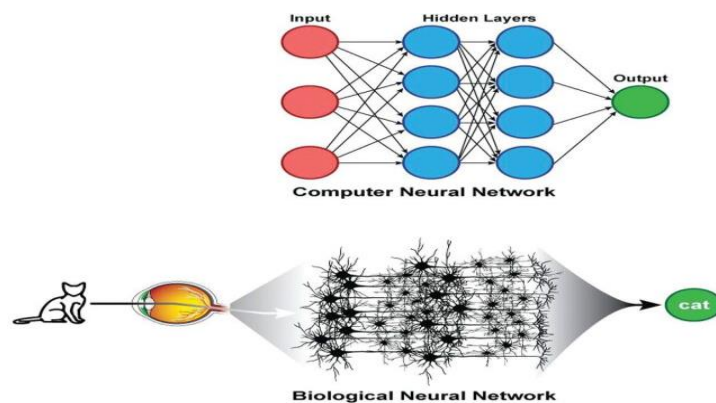
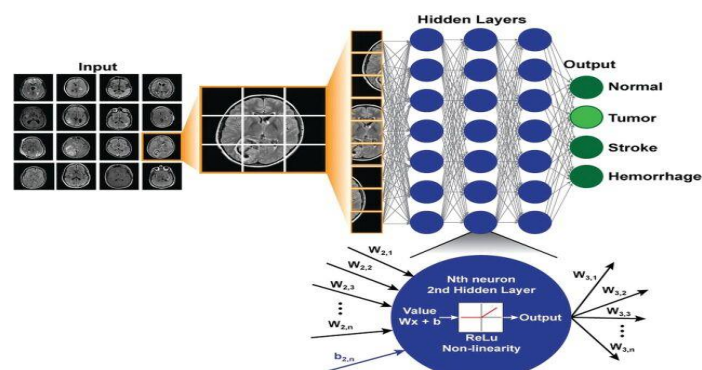


Figure 1 Architectural model of computer and human neural networks

Deep learning is the most widely applied supervised machine learning method, especially in medical imaging or radiology. The deep learning method is a method that can classify data automatically using neural networks as an architectural model because it is inspired by the structure of neural networks in the brain (Figure 1). Simple deep-learning models can receive image data serving as "*neuron*" input for neuroimaging. Although the example below uses individual images as input, the input can generally be a series of photos from several modalities. Once the input is received, we must determine how many layers (how deep) and how many neurons per layer (how comprehensive) to include; this is known as the network architecture (Figure 2). Then, after that, they will be classified into several groups according to the data that trains the algorithm from the AI machine (Liu et al., 2018; Yasaka & Abe, 2018; Montagnon et al., 2020; Litjens et al., 2017).



**Figure 2 Simple example of neural network architecture
for deep learning methods**

The Role of Deep Learning Methods in Clinical Affairs

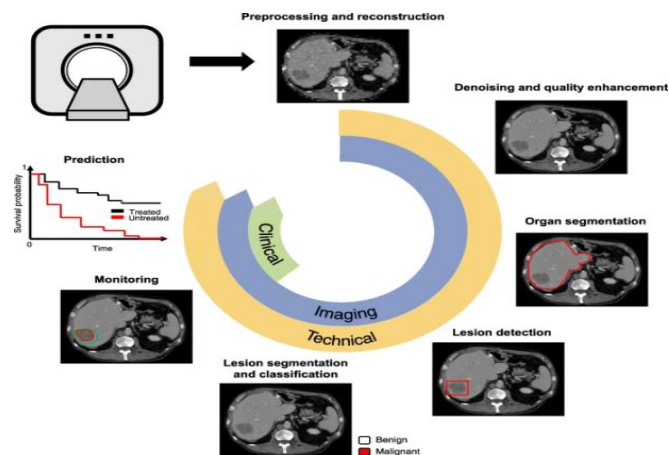


Figure 3 The role of deep learning methods in clinical practice

Deep learning methods can quickly perform tasks that are time-consuming manually by radiologists, such as detecting lesions, segmentation, classification, monitoring, and predicting treatment response (Figure 3). In the case of EDH, it will only focus on the initial processing and classification stages. In the initial processing stage, the input data entered is processed; then reconstruction will be carried out if necessary, which can improve the quality of the data, and reduce noise and artefacts contained in the data (Figure 4). Then, the classification stage is carried out to categorize specific groups using the random tree learner (RTL) algorithm by producing a decision tree to determine whether the input entered is normal or EDH (Drozdal et al., 2018; Gillies et al., 2016; Yasaka et al., 2018; Luo et al., 2016).

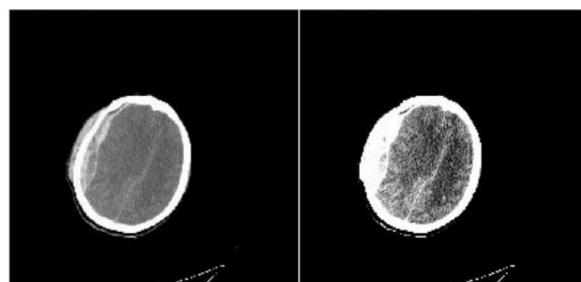


Figure 4 CT-Scan input, which has been processed and improved in quality

Use of the Early Warning System for early detection of EDH

An Early Warning System (EWS) is proposed to help radiologists scan all skull CT scans obtained from the emergency room. This system is designed to make decisions about the possibility of EDH or not in patients with head injuries. EWS is integrated with email so that if there is EDH in 2 images from the same CT-Scan set, EWS will send an email to the practitioner along with an image attachment indicating EDH to take immediate action. If there is EDH in more than ten images from the same set, then EWS will send the information with a note of high importance. In a previous study, testing of 27 patients was carried out, and it was found that 13 of the 27 patients were diagnosed with EDH, with 85% having high-importance records (Table 1) (Lao et al., 2017; Lee et al., 2017; Akkus et al., 2017; Vieira et al., 2017; Aydoseli et al., 2022).

Table 1 EWS Test Results

EWS Test Results (27)	EDH	Normal	Total
<i>(High Importance)</i> Prediction	11	0	11
<i>(Low Importance)</i> Prediction	2	3	5
Normal Prediction	0	11	11
Total	13	14	27

CONCLUSION

Head injuries are one of the highest causes of death and, therefore, need to be treated immediately. Manifestations of head injury can be accompanied by bleeding, one of which is epidural bleeding or epidural hematoma (EDH). EDH is bleeding in the area between the dura mater and the internal tabula, which needs to be confirmed using a CT scan. As technology develops in the health sector, especially medical imaging, the application of artificial intelligence continues to be discovered to help radiologists, one of which is the Early Warning System (EWS), which can help radiologists detect early the possibility of EDH in patients with head injuries so that can be treated quickly by health practitioners. This method is more profitable for radiologists considering that the process does not take long enough for emergency conditions so that treatment can be given quickly and can reduce the death rate of patients with head injuries.

REFERENCES

- Akkus, Zeynettin, Galimzianova, Alfiia, Hoogi, Assaf, Rubin, Daniel L., & Erickson, Bradley J. (2017). Deep learning for brain MRI segmentation: state of the art and future directions. *Journal of Digital Imaging*, 30, 449–459.
- Ansar, Joan Willy, Anggorotomo, Wirawan, Utami, Deviani, & Virdaus, Nur Alam. (2021). Gambaran Klinis Pasien Epidural Hematoma Di RSUD Dr. H. Abdul Moeloek Provinsi Lampung. *Jurnal Ilmu Kedokteran Dan Kesehatan*, 8(3).
- Astuti, Ewi, Saanin, Syaiful, & Edison, Edison. (2016). Hubungan Glasgow Coma Scale Dengan Glasgow Outcome Scale Berdasarkan Lama Waktu Tunggu Operasi Pada Pasien Perdarahan Epidural. *Majalah Kedokteran Andalas*, 39(2), 50–57.
- Awaloei, Astrid C., Mallo, Nola T. S., & Tomuka, Djemi. (2016). Gambaran cedera kepala yang menyebabkan kematian di Bagian Forensik dan Medikolegal RSUP Prof Dr. E-CliniC, 4(2).
- Aydoseli, Aydin, Unal, Tugrul Cem, Kardes, Onur, Doguc, Ozge, Dolas, Ilyas, Adiyaman, Ali Ekrem, Ortahisar, Emircan, Silaharoglu, Gokhan, Aras, Yavuz, & Sabanci, Pulat Akin. (2022). An early warning system using machine learning for the detection of intracranial hematomas in the emergency trauma setting. *Turkish Neurosurgery*, 32(3).
- Azimah, Fauzan, & Rizky Nova Wardani, Kiky. (2022). Sistem Pendeteksi Gejala Awal Covid-19 dengan Penggunaan Metode Al Project Cycle. *Journal Locus Penelitian Dan Pengabdian*, 1(6), 405–418. <https://doi.org/10.36418/locus.vii6.135>
- Brynjolfsson, Erik, Mitchell, Tom, & Rock, Daniel. (2018). What can machines learn and what does it mean for occupations and the economy? *AEA Papers and Proceedings*, 108, 43–47. American Economic Association 2014 Broadway, Suite 305, Nashville, TN 37203.
- Darmayanti, Dewi, & Armaiyn, Liasari. (2020). Karakteristik Hasil Ct Scan Kepala Non Kontras Penderita Cedera Kepala Di Rsd Kota Tidore Kepulauan Tahun 2018. *Kieraha Medical Journal*, 2(2), 104–108.
- Drozdal, Michal, Chartrand, Gabriel, Vorontsov, Eugene, Shakeri, Mahsa, Di Jorio, Lisa, Tang, An, Romero, Adriana, Bengio, Yoshua, Pal, Chris, & Kadoury, Samuel. (2018). Learning normalized inputs for iterative estimation in medical image segmentation. *Medical Image Analysis*, 44, 1–13.
- Gillies, Robert J., Kinahan, Paul E., & Hricak, Hedvig. (2016). Radiomics: images are more than pictures, they are data. *Radiology*, 278(2), 563–577.
- Hassabis, Demis, Kumaran, Dharshan, Summerfield, Christopher, & Botvinick, Matthew. (2017). Neuroscience-inspired artificial intelligence. *Neuron*, 95(2), 245–258.
- Hosny, Ahmed, Parmar, Chintan, Quackenbush, John, Schwartz, Lawrence H., & Aerts, Hugo J. W. L. (2018). Artificial intelligence in radiology. *Nature Reviews Cancer*, 18(8), 500–510.
- Jiang, Feng, Ma, Ling, Broyd, Tim, & Chen, Ke. (2021). Digital twin and its implementations in the civil engineering sector. *Automation in Construction*, 130, 103838.
- Katzman, Benjamin D., van der Pol, Christian B., Soyer, Philippe, & Atlas, Michael N. (2023). Artificial intelligence in emergency radiology: A review of applications and possibilities. *Diagnostic and Interventional Imaging*, 104(1), 6–10.

- Lao, Jiangwei, Chen, Yinsheng, Li, Zhi Cheng, Li, Qihua, Zhang, Ji, Liu, Jing, & Zhai, Guangtao. (2017). A deep learning-based radiomics model for prediction of survival in glioblastoma multiforme. *Scientific Reports*, 7(1), 10353.
- LeCun, Yann, Bengio, Yoshua, & Hinton, Geoffrey. (2015). Deep learning. *Nature*, 521(7553), 436–444.
- Lee, June Goo, Jun, Sanghoon, Cho, Young Won, Lee, Hyunna, Kim, Guk Bae, Seo, Joon Beom, & Kim, Namkug. (2017). Deep learning in medical imaging: general overview. *Korean Journal of Radiology*, 18(4), 570–584.
- Litjens, Geert, Kooi, Thijs, Bejnordi, Babak Ehteshami, Setio, Arnaud Arindra Adiyoso, Ciompi, Francesco, Ghafoorian, Mohsen, Van Der Laak, Jeroen Awm, Van Ginneken, Bram, & Sánchez, Clara I. (2017). A survey on deep learning in medical image analysis. *Medical Image Analysis*, 42, 60–88.
- Liu, Fang, Jang, Hyungseok, Kijowski, Richard, Bradshaw, Tyler, & McMillan, Alan B. (2018). Deep learning MR imaging–based attenuation correction for PET/MR imaging. *Radiology*, 286(2), 676–684.
- Luo, Wei, Phung, Dinh, Tran, Truyen, Gupta, Sunil, Rana, Santu, Karmakar, Chandan, Shilton, Alistair, Yearwood, John, Dimitrova, Nevenka, & Ho, Tu Bao. (2016). Guidelines for developing and reporting machine learning predictive models in biomedical research: a multidisciplinary view. *Journal of Medical Internet Research*, 18(12), e323.
- Malik, Paras, Pathania, Monika, & Rathaur, Vyas Kumar. (2019). Overview of artificial intelligence in medicine. *Journal of Family Medicine and Primary Care*, 8(7), 2328.
- Manarisip, Miranda Esther Irene, Oley, Maximillian Ch, & Limpeleh, Hilman. (2014). Gambaran Ct Scan Kepala Pada Penderita Cedera Kepala Ringan Di Blu Rsup Prof. Dr. Rd Kandou Manado Periode 2012–2013. *E-CliniC*, 2(2).
- Mello-Thoms, Claudia, & Mello, Carlos A. B. (2023). Clinical applications of artificial intelligence in radiology. *The British Journal of Radiology*, 96, 20221031.
- Montagnon, Emmanuel, Cerny, Milena, Cadrin-Chênevert, Alexandre, Hamilton, Vincent, Derennes, Thomas, Ilinca, André, Vandenbroucke-Menu, Franck, Turcotte, Simon, Kadoury, Samuel, & Tang, An. (2020). Deep learning workflow in radiology: a primer. *Insights into Imaging*, 11, 1–15.
- Mwangi, Benson, Soares, Jair C., & Hasan, Khader M. (2014). Visualization and unsupervised predictive clustering of high-dimensional multimodal neuroimaging data. *Journal of Neuroscience Methods*, 236, 19–25.
- Pedersen, Tore, Johansen, Christian, & Jøsang, Audun. (2018). Behavioural Computer Science: an agenda for combining modelling of human and system behaviours. *Human-Centric Computing and Information Sciences*, 8(1), 1–20.
- Rawis, Maria L., Lalenoh, Diana Ch, & Kumaat, Lucky T. (2016). Profil pasien cedera kepala sedang dan berat yang dirawat di ICU dan HCU. *E-CliniC*, 4(2).
- Rudyanto, Dansen Frans Louise Draven, Patongai, Fikri Muhammad Rifai, & Suharmanto, Suharmato. (2023). Epidural Hematoma pada Laki-Laki 29 Tahun. *Jurnal Agromedicine*, 10(2), 14–18.

- Siahaya, Noviyanter, Huwae, Laura B. S., Angkejaya, Ony W., Bension, Johan B., & Tuamelly, Jacky. (2020). Prevalensi kasus cedera kepala berdasarkan klasifikasi derajat keparahannya pada pasien rawat inap di rsud dr. m. haulussy ambon pada tahun 2018. *Molucca Medica*, 14–22.
- Vieira, Sandra, Pinaya, Walter H. L., & Mechelli, Andrea. (2017). Using deep learning to investigate the neuroimaging correlates of psychiatric and neurological disorders: Methods and applications. *Neuroscience & Biobehavioral Reviews*, 74, 58–75.
- Yasaka, Koichiro, & Abe, Osamu. (2018). Deep learning and artificial intelligence in radiology: Current applications and future directions. *PLoS Medicine*, 15(11), e1002707.
- Yasaka, Koichiro, Akai, Hiroyuki, Abe, Osamu, & Kiryu, Shigeru. (2018). Deep learning with convolutional neural network for differentiation of liver masses at dynamic contrast-enhanced CT: a preliminary study. *Radiology*, 286(3), 887–896.
- Yunus, Muhamad, Wahyudi, Alfi, Febriyani, Arti, & Romiza, Rona Asla. (2020). Karakteristik Hasil CT-Scan Kepala pada Penderita Cedera Kepala di Rumah Sakit Dr. H. Abdul Moeloek periode Januari–Desember Tahun 2018. *ARTERI: Jurnal Ilmu Kesehatan*, 1(3), 177–183.