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The Diminishing Role of Skull X-Rays in Trauma Brain Injury: A Comprehensive Review of the Literature

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ABSTRACT

Background: Skull X-rays have long been utilized in the evaluation and management of traumatic brain injury (TBI) primarily for the identification of cranial fractures. However, their role has been challenged by the introduction of advanced neuroimaging techniques. **Objectives**: This review aims to explore the current significance of skull X-rays in the treatment of TBI, considering the advancements in neuroimaging, especially CT Scan. **Methods**: A narrative review approach was used, including a comprehensive computerized literature search with MeSH-based keywords "Traumatic Brain Injury" and "Skull X-Ray" across several reputable databases such as Scopus, PubMed, and Web of Science. The search spanned the years 2000 to 2025 and aimed to evaluate the diagnostic utility of skull radiography in TBI, focusing specifically on different age groups, specifically those under and over 2 years of age. **Conclusion**: Current evidence suggests that skull X-rays have limited sensitivity in detecting intracranial injuries, which are the primary concern in cases of TBI. Therefore, clinical judgment should guide the decision to pursue CT imaging instead of relying solely on skull X-rays. The routine use of skull X-rays in managing TBI is thus discouraged because of their limited diagnostic capabilities and the potential risk of delaying timely and appropriate medical intervention.

Keywords: Skull X-rays, Traumatic Brain Injury.

ABSTRAK

Latar Belakang: Rontgen tengkorak telah lama digunakan dalam evaluasi dan manajemen cedera otak traumatis terutama untuk identifikasi fraktur kranial. Namun, peran rontgen tengkorak telah dipertanyakan oleh karena adanya teknik *neuroimaging* yang lebih canggih. **Tujuan:** Tinjauan ini bertujuan untuk mengeksplorasi relevansi kontemporer dari rontgen tengkorak dalam manajemen cedera kepala traumatis, dengan mempertimbangkan kemajuan dalam *neuroimaging*, khususnya *CT Scan*. **Metode:** Pendekatan tinjauan naratif digunakan, dengan melibatkan pencarian literatur komputerisasi yang menyeluruh menggunakan kata kunci berbasis MeSH "Traumatic Brain Injury" dan "Skull X-Ray" di beberapa basis data terkemuka seperti Scopus, PubMed, dan Web of Science. Pencarian mencakup tahun 2000 hingga 2025 dan bertujuan untuk menilai kegunaan diagnostik rontgen tengkorak dalam cedera kepala traumatis dengan perhatian khusus pada kelompok usia yang berbeda, khususnya mereka yang berusia di bawah dan di atas 2 tahun. **Kesimpulan:** Bukti saat ini menunjukkan bahwa rontgen tengkorak memiliki sensitivitas terbatas dalam mendeteksi cedera intrakranial yang merupakan perhatian utama dalam kasus cedera kepala traumatis. Oleh karena itu, penilaian klinis harus menjadi dasar keputusan untuk melakukan *CT Scan* daripada hanya mengandalkan rontgen tengkorak. Oleh karena itu, penerapan rutin rontgen tengkorak dalam manajemen cedera kepala traumatis tidak dianjurkan karena kemampuan diagnostik yang terbatas dan risiko menghambat intervensi medis yang tepat waktu dan sesuai.

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Kata kunci: Cedera Kepala Traumatis, Rontgen Tengkorak.

1. Introduction

Traumatic Brain Injury (TBI) is characterized as a pathological state resulting from the disruption of normal cerebral function, induced by mechanical forces such as a contusion, impact, or penetrating trauma to the head.[1] Neuroimaging techniques are pivotal in the comprehensive management and diagnosis of TBI, facilitating informed clinical decision-making and targeted therapeutic interventions.[2] In the past, skull x-ray has been employed to identify cranial fractures, intracranial mass effects, air-fluid levels, and the presence of foreign bodies. Nevertheless, conventional skull x-rays exhibit intrinsic limitations, as these imaging modalities do not adequately depict intracerebral structures, and are therefore insufficient for the identification of intracranial hemorrhages or other cerebral pathologies.[3,4] In modern clinical practice, the utilization of skull radiographs in the assessment of head injuries has been largely replaced by CT Scan, which delivers enhanced diagnostic sensitivity and specificity for TBI.[5] The 2023 guidelines issued by the National Institute for Health and Care Excellence (NICE) have transitioned away from recommending skull radiographs as the primary imaging technique for traumatic brain injury (TBI), suggesting their use only in specific cases following expert consultation with neurology or neurosurgery specialists.[6]

However, in resource-constrained settings like Indonesia, skull X-rays play a critical diagnostic role due to the limited availability of advanced imaging techniques, including CT scans and magnetic resonance imaging (MRI), along with a shortage of trained radiologists. Clinicians frequently depend on basic diagnostic measures, such as skull X-rays, before triaging patients to higher-level medical institutions for further evaluation.[7,8] Additionally, there is a growing interest in the utilization of X-rays in pediatric patients, particularly among children under two years of age, whose skulls exhibit greater deformability due to anatomical differences such as thinner bones and unfused sutures.[9,28] In this population, isolated skull fractures—a term referring to cranial fractures without any intracranial pathology—are relatively common occurrences.[10,11] The application of head CT scan in these cases is often intriguing, since this population is susceptible to the adverse effects associated with CT scan radiation.[12] Two systematic reviews have documented similar findings, indicating that the overutilization rate of head CT scans in pediatric patients with mild TBI was almost 30%.[13,14]

Thus, although skull radiography is no longer considered the gold standard in the imaging of head trauma, it maintains clinical relevance in specific circumstances, highlighting its ongoing significance in global health practice. Accordingly, this study aims to investigate the role of X-rays in managing traumatic brain injury (TBI) based on the current literature.

2. Method

A systematic computer-based literature review was conducted to identify relevant articles from Scopus, PubMed, and Web of Science databases. The search utilized modified Medical Subject Headings (MeSH) terms, specifically targeting “Traumatic Brain Injury” and “Skull X-Ray." Selected studies met the following inclusion criteria: (1) Published after the year 2000; (2) Evaluating the role of skull X-rays in the management of traumatic brain injury, i.e mild, moderate, and severe; and (3) Including subjects of all ages. Exclusion criteria comprised: (1) Studies lacking full-text availability; and (2) Sytematic review and meta-analysis. This review addressed two key focal points: the sensitivity and specificity of skull X-rays in detecting intracranial injuries, and the role of skull X-rays in evaluating pediatric traumatic brain injury (TBI) in children under two years of age.

3. Discussion

3.1 Sensitivity and Specificity of Skull X-Ray in Detecting Intracranial Injury

Skull radiographs demonstrate a markedly low sensitivity for the identification of intracranial injuries. A comparative study revealed a sensitivity of 0.00% when evaluated in relation to CT Scan.[15] Furthermore, another investigation found a sensitivity of 38.2%, which further emphasizes the inadequacy of skull radiographs as reliable diagnostic modalities for intracranial injuries.[15] In contrast, these radiographs exhibit relatively high specificity. One research report indicated a specificity of 94%,[16] while another study reported it at 93.2%.[15] This suggests that, although skull radiographs can effectively identify patients without intracranial injuries, they often miss numerous cases of intracranial injury.

In comparison, CT scans exhibit significantly greater sensitivity and specificity for detecting intracranial injuries. Research indicates that CT scans have a sensitivity of 95.3% and a specificity of 96.4%, establishing them as the gold standard for accurately identifying intracranial injuries.[16,17] On the other hand, magnetic resonance imaging (MRI) demonstrates sensitivity rates of up to 100% for detecting such injuries. However, its use in acute situations is limited due to the necessity of sedation for young children and the prolonged duration of the scans.[18,19] Additionally, when compared to skull X-rays, clinical parameters—such as the patient's age, the mechanism of injury, and neurological symptoms—can effectively identify patients without intracranial injuries with similar accuracy.[20,21] The Glasgow Coma Scale (GCS) at the time of presentation is recognized as a key clinical predictor of intracranial injury, with a GCS score of 13 showing a statistically significant correlation with positive CT findings for intracranial injuries.[22]

3.2 Skull X - Ray in Subjects Aged Less than Two Years

Head trauma resulting from blunt force impacts, particularly among children younger than two years, frequently occurs due to falls, accidental drops, or non-accidental injuries (NAIs). Skull fractures can occur in up to 30% of these cases.[23,24] This vulnerability is often attributed to a relatively larger head-to-body ratio, thinner skull bones, and softer, less myelinated nerve tissue in this age group.[25,26]

In assessing the risk of clinically significant traumatic brain injury (CITBI), which encompasses intracranial injuries (ICI), emergency head CT scans and consultations with neurosurgeons may be necessary. Skull X-rays can assist in identifying linear fractures with diastasis exceeding 4 mm, as well as depressed or comminuted fractures. Skull X-rays have been a common diagnostic tool in managing head injuries due to their minimal radiation exposure to children.[27] According to the Canadian Paediatric Society, children under two years old who endure mild head trauma and present with significant soft tissue hematomas may require skull fracture screening.[28]

Despite their rapid and widespread availability for analyzing cranial sutures and potential skull fractures, skull X-rays have limitations. They possess a reduced sensitivity for detecting specific fractures and subtle anomalies and are unable to identify intracranial conditions that may only become apparent as the patient's situation deteriorates, such as intracranial hemorrhage.[29] Therefore, it is essential that interpretations of skull X-rays be conducted by pediatric radiologists or similarly qualified specialists, such as pediatric neurosurgeons. Different interpretations by non-specialist physicians may lack the specificity and sensitivity required for accurate diagnosis.[28,30] For instance, pediatric emergency physicians assessing skull X-rays of children under two demonstrated a sensitivity of 76% and a specificity of 84%.[31] However, the sensitivity can decline to 38% when assessed by less experienced or pressure-stressed emergency clinicians, while specificity remains high at 95%.[32]

Several experts argue against the routine use of skull X-rays in assessing children with mild head injuries. The likelihood of detecting skull fractures through radiographs after mild trauma is low, and the necessity for neurosurgical intervention is unusual. Consequently, routine skull radiography may be unnecessary, with CT scans being the more appropriate diagnostic tool for cases presenting neurological symptoms.[33] One study indicated that all fractures visible on a skull X-ray were also identifiable on a head CT, suggesting that head X-rays offer no diagnostic advantage when a CT with 3D reconstruction is accessible.[29] Excluding anteroposterior (AP) and lateral skull X-rays from initial skeletal surveys could decrease radiation exposure and patient stress while also streamlining the diagnostic process.[29]

3.3 Skull X-ray in Various Guidelines for Assessing TBI

Recent guidelines from organizations such as the Royal College of Surgeons of England (RCSE) and the National Institute for Health and Care Excellence (NICE) advise against using skull X-rays for cases of mild traumatic brain injury (TBI). For over twenty years, the efficacy of skull X-rays in diagnosing head injuries has been questioned. The Royal College of Surgeons of England (RCSE) issued revised guidelines intended for hospitals with 24-hour access to CT scans. Similarly, a 2003 report from NICE emphasized concerns about the necessity of skull X-rays, particularly in facilities where CT scans are readily accessible.[34] One of the key benefits of CT imaging in assessing head injuries is its sensitivity for depicting intracranial mass effects, evaluate ventricular size and configuration, and detect bone fractures, as well as acute intracranial hemorrhages, regardless of their location—whether parenchymal, subarachnoid, subdural, or epidural.[35] Skull X-rays notably have a low sensitivity of only 38% in detecting intracranial hemorrhages, leading to the conclusion that they offer no valid indications for use in adult patients.[34]

4. Conclusion

Skull X-rays, historically significant in addressing traumatic brain injury (TBI), now demonstrate limited diagnostic effectiveness in the modern era. Their capacity to detect intracranial injuries—a critical aspect of TBI—is notably low, making them insufficient as a standalone diagnostic option. While these radiographs can identify cranial fractures, such findings seldom influence management strategies, particularly when compared to the detailed insights provided by CT scans. Consequently, clinicians are encouraged to conduct comprehensive clinical evaluations, considering variables such as the patient's age, the mechanism of injury, and their neurological condition. These assessments should inform the decision to utilize CT imaging, thereby ensuring that patients benefit from the most suitable and effective diagnostic methods. Therefore, the routine application of skull X-rays in TBI management is discouraged; it may hinder timely diagnosis, subject patients to unnecessary radiation exposure, and lead to less than optimal health outcomes.

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