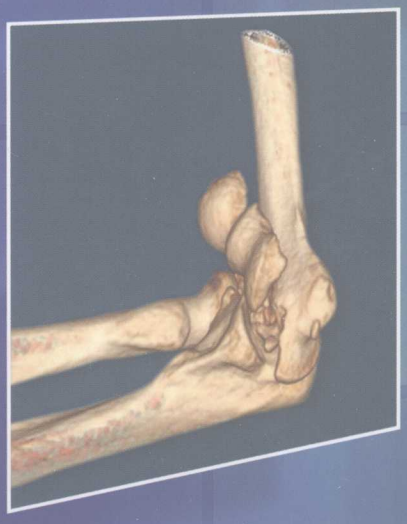
Harris & Harris' Radiology of Emergency Medicine

FIFTH EDITION

Thomas L. Pope, Jr. • John H. Harris, Jr.



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The Radiology of Emergency Medicine

FIFTH EDITION

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Designer: Teresa Mallon
Production Service: Absolute Service, Inc.

Two Commerce Square
2001 Market Street
Philadelphia, PA 19103 USA
LWW.com

Printed in China

Library of Congress Cataloging-in-Publication Data

Harris & Harris' radiology of emergency medicine / edited by Thomas L. Pope Jr. ; co-editor John H. Harris Jr. — 5th ed.
p. ; cm.
Radiology of emergency medicine
Rev. ed. of: Radiology of emergency medicine / John H. Harris Jr., William H. Harris. 4th ed. c2000.
Includes bibliographical references and index.
ISBN 978-1-4511-0720-3 (hardback : alk. paper)
I. Pope, Thomas Lee. II. Harris, John H., 1925- III. Harris, John H., 1925- Radiology of emergency medicine. IV. Title: Radiology of emergency medicine.
[DNLM: 1. Emergencies. 2. Emergency Medicine—methods. 3. Radiography—methods. WB 105]

616.07'572—dc23
2012030187

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I dedicate this book to the uncountable number of fellows, residents, and medical students with whom I have interacted in my career. All of them have taught me aspects of lifelong learning in some way which all humans, especially physicians, should embrace and practice with enthusiasm and commitment; to my two sons, David and Jason, whom I know live their lives by this basic principle; and lastly, to my significant other, Dr. Jennifer Newcomb Cranny, who is a constant and solid pillar of support for me personally and professionally.

—TLP, Jr.

To the members of the Church of the Red Rocks (Sedona, Arizona), whose steadfast love and support sustained my wife, Cathy, and I during her terminal illness, and which will sustain me the rest of my life.

—JHH, Jr.

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FOREWORD

It is indeed a pleasure and an honor to be asked to write the introduction for the fifth edition of *The Radiology of Emergency Medicine*, edited by Thomas L. Pope, Jr., and John H. Harris, Jr. This "classic" textbook was well known to me as a resident in general surgery during my rotation in the emergency department (ED). Also, when Dr. Harris "retired" from his position at the University of Texas-Houston and came to Arizona, he was introduced to me as the "guy who wrote the book on emergency radiology." I soon realized that this statement was true, both literally and figuratively. For the past 40 years, Dr. John Harris' dedication to his colleagues in radiology and his intellectual connection to emergency medicine physicians and trauma surgeons make this textbook "the standard reference" for diagnostic imaging for emergency medicine and trauma. He is one of those rare radiologists who comes out of the "bat cave" into the light of the trauma bay and the ED to give real-time interpretations and discussions of patient images. On countless occasions, I have found Dr. Harris in our trauma receiving area, reviewing radiographs and teaching our residents and attendings the nuances of interpreting conventional radiographs.

The fifth edition has again strived to keep up with the changing technology in diagnostic imaging in addition to emphasizing current practice in EDs and trauma centers. New chapters on imaging of skull fractures, maxillofacial trauma, chest trauma, and the acetabulum have been added to this volume to emphasize the importance of these areas with respect to imaging techniques and changes in clinical diagnosis and practice. In addition to redefining the importance of standard radiographs, the fifth edition has incorporated high-quality multidetector computed tomographic (CT) images, 3-D reformations, and magnetic resonance imaging to provide new information with evolving clinical practice. For example, the chapter dedicated to chest trauma not only highlights the importance of technical factors in interpreting emergency chest radiographs but also emphasizes the increasing reliance on CT diagnosis. Moreover, the chapter has added numerous sources of practical information not only for the radiologist but also for clinicians involved in the direct care of the patient.

Finally, the editors' devotion to fields as dynamic as radiology and emergency care is evident in the effort that has been taken to contemporize the fifth edition. It will continue to be requisite reading for radiology residents, experienced radiologists, and clinicians alike. Also, the images that are available on the online version of this edition will provide ongoing, valuable educational resources for residents, radiology and emergency medicine faculty, and frontline physicians for years to come.

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PREFACE TO THE FIFTH EDITION

I am very proud to welcome Tommy Pope, MD—an internationally recognized musculoskeletal radiologist—as coeditor of the fifth edition of *The Radiology of Emergency Medicine*. Tommy's reputation throughout the world radiologic community precludes the need for a more formal introduction here.

It was Dr. Pope's recommendation that we obtain new coauthors for nearly every chapter, which has been accomplished. It was Dr. Pope's suggestion that we should recruit non-American musculoskeletal chapter authors. That, also, has been accomplished, and their contributions are beautifully visible in the chapters dealing with the appendicular skeleton. So, Dr. Pope is the logical choice to perpetuate *The Radiology of Emergency Medicine* in future editions.

It is interesting to reflect that in the first edition of this book, published by Williams and Wilkins in 1975, it contained 14 chapters and nearly 500 pages. The first chapter on the "Skull" consisted of 24 pages and 39 figures devoted to conventional radiography of the skull, including such topics as the distinction between skull fractures and sutures, the various radiographic appearance of skull fractures, and methods of determining pineal gland displacement as a manifestation of increased intracranial pressure or midline shift.

In 1975, conventional radiography was the primary diagnostic tool of the emergency department physician and what few subspecialists there were at that time. Also, very few clinical radiologists and radiologic physicists had more than an inkling of what the future of imaging would become in the 21st century. Today, imaging is the cornerstone of emergent diagnosis. It is now common, because of multiplanar computed tomography (MPCT) in, or adjacent to, the trauma bay and the availability of MPCT in the evaluation of nontrauma emergency department patients, that the patient's definitive diagnosis is established or confirmed before leaving the trauma bay or the emergency department.

The fifth edition of *The Radiology of Emergency Medicine* consists of 23 chapters, including six new chapters and approximately 1,000 pages replete with state-of-the-art MPCT and ultrasound (US) images germane to conditions which prompt patient emergency department or trauma visits. Each chapter has been extensively revised to include contemporary imaging indications and protocols. This edition contains more than 2,000 images or schematic anatomic drawings of the manuscript.

While I believe each chapter to be a vast improvement of those in the fourth edition, some, in my opinion, deserve special recognition. Anthony Wilson, MD, has, as his final academic effort, prepared for the readers the clearest, most succinct, and the most understandable descriptions of both the Letournel classification of acetabular fractures and of the Lauge-Hansen classification of ankle injuries I have ever read.

Chapter 4, "Face, Including Intraorbital Soft Tissues and Mandible," is one of my favorite topics and one which I think I have explained well in prior editions. Dr. Mark Bernstein's revision of this chapter has elevated the bar of intellectual sophistication while, at the same time, continuing to present the imaging aspects of the complex concepts of facial trauma in a lucent, understandable, and practical fashion.

Dr. Richard Daffner's revision of the "Cervical Spine," Chapter 5, is an exemplary example of blending his concepts of cervical spine injuries with mine, which have been somewhat at variance over the years, into a traditionally organized and beautifully written chapter. Dr. Daffner's revision should provide the reader with a clear understanding of the complexities of cervical spine.

A very significant positive addition to the fifth edition is the contribution of our non-American authors; although the images of musculoskeletal trauma are universally similar, their description and understanding from the unique European perspective provides interesting and occasionally challenging reading. The addition of the European

authors to our work has enhanced the stature of our text.

The purpose of the fifth edition of *The Radiology of Emergency Medicine* is to present to the reader, regardless of their experience in interpreting images of acutely ill and injured patients, the contemporary concepts and philosophies of the imaging of any patient presenting to the imaging department. It is intended for imagers but could also be appreciated by any and every physician who sees patients in the emergency setting. It is our sincere hope that, by virtue of its contemporary and authoritative contents, emergent patient care will be in some way enhanced and that the patients seen in this setting will receive better and more complete care because of all of our efforts.

John H. Harris, Jr., MD, DSc

PREFACE TO THE FIRST EDITION

Radiology, and the radiologist, can be of invaluable assistance in the assessment of the acutely ill or injured patient. The radiology of emergency medicine occupies a minor position in the curriculum of most medical schools and radiology training programs. Consequently, physicians involved in the care of emergency patients have varied experience and training in the radiology related to this aspect of medicine.

The purpose of this work is to describe the role of radiology in the appraisal of the acutely ill or injured patient, to emphasize and illustrate its value as well as its limitations, and to guide the physician in the roentgen diagnosis of the emergency patient. It is hoped that this will provide a better understanding of appropriate roentgen examination to be requested and the information that the study can be reasonably expected to provide.

It is not our intent to present radiographic examples of every disease entity that might prompt an emergency department patient visit, nor is it our intent to present any entity described herein exhaustively. Many textbooks and articles exist which do provide such comprehensive roentgen descriptions.

Rather, it is our purpose to focus upon those radiologic aspects of emergency medical care which, in our experience, have acted as "pitfalls" to the examination, diagnosis, and understanding of emergency medical problems. Every illustration has been chosen from our personal practices to illustrate a point which, at some time or other, has presented some degree of difficulty. Emphasis has always been placed upon objective, although frequently subtle, changes which should lead to the correct radiographic diagnosis.

While the prime motivation for this effort has been a desire to be of assistance to emergency department physicians, it is hoped that the book will be of value to physicians of all disciplines involved in the diagnosis and management of the acutely ill or injured patient.

John H. Harris, Jr., MD, DSc
William H. Harris, MD

ACKNOWLEDGMENTS

As the historical author of Harris and Harris' *The Radiology of Emergency Medicine*, I have usurped the privilege of preparing the Acknowledgments.

First and foremost, this 5th Edition would not have seen the light of day were not for the interest, wisdom, and guidance of Charlie Mitchell, previously of LWW, or without the enthusiastic, energetic participation of Tommy Pope, my co-editor, who is personally responsible for recruiting many new authors including those wonderful UK authors whose European concepts illuminate several chapters of this edition.

Tommy and I deeply appreciated the work done by all the first-time authors, many of whom are members of The Society of Emergency Radiology, and we look forward to their continued involvement in the perpetuation of this text.

Anthony Wilson's contributions to this edition have been previously described. However, Dr. Wilson's work is notable for two reasons: his concepts of the Letournel classification of acetabular fractures and of the Lauge-Hansen classification of ankle fractures, and his ability to convey these complex concepts in understandable language is truly unique. For the first time, in my experience, these classifications are comprehendible. Further, his contributions to this edition complete his life-long advancement of Radiologic knowledge, thus making this text the sole published source of Dr. Wilson's remarkable understanding of these difficult concepts.

On the technical side, Tommy and I thank Jonathan Pine, Senior Executive Editor, Ryan Shaw, former Product Manager, and Amy Dinkel, Product Manager, all of Lippincott Williams & Wilkins, and Teresa Exley of Absolute Service, Inc. Personally, I thank Wendy Hansen and Peggy Keys-Farley, Sedona (Arizona) Photo for their accurate and a gracious production of images required for my work when that service was not otherwise available.

Tommy Pope, MD, Co-Editor
John H. Harris, Jr., MD, DSc, Co-Editor

CONTENTS

CHAPTER 1

Skull Fractures

Ken F. Linnau ■ John H. Harris Jr.

CONTEXT AND EPIDEMIOLOGY

Since ancient times, humans are believed to have treated trauma to the head and skull. Anthropologic evidence suggests that the Incas in Peru have used trepanation techniques for treatment of skull fractures as early as 200 BC, and current treatment techniques have evolved from the observations and practices of Greek and Roman physicians.[1,2]

This chapter illustrates and describes the imaging characteristics of acute injury of the cranial bones at the initial patient encounter in the emergency center. The true incidence of skull fractures in children and adults presenting to emergency departments (ED) is unknown and much of the data is derived from traumatic brain injury (TBI) evaluation, which affects about 1.7 million patients every year and accounts for up to 1.4 million annual ED visits in the United States (2006 data).[3] About 300,000 TBI patients are hospitalized annually and about 4% of patients treated for head trauma have a skull fracture.[4] The most common causes of TBI include falls (35%), motor vehicle crashes (MVC) (17%), assaults (10%), and being struck by or against an object. Falls show the highest rates in children less than 4 years and adults older than 75 years of age. MVC injury is the leading cause of TBI-related death, particularly in young adults who are less than 24 years old.

In children, intentional injury (i.e., nonaccidental trauma, abusive head trauma) represents an important cause of skull fractures and associated morbidity such as intracranial hemorrhage and retinal bleeding.[5]

INDICATIONS FOR IMAGING AND SUPPORTING EVIDENCE

Indiscriminate use of skull radiographs triggered one of the earliest assessments for rational imaging use. In 1987, a prospective study of ED patients was performed to validate an expert guideline, which recommended that low-risk patients should not undergo routine skull radiography after head trauma in order to reduce radiation exposure and imaging cost.[6,7] Today, computed tomography (CT) is the imaging modality of choice in the initial evaluation of patients with emergent cranial and intracranial signs and symptoms. The need for imaging is usually based on the severity of head injury as indicated by initial Glasgow Coma Scale (GCS) (Table 1.1). With this scale, the three main aspects of neurologic function evaluated are (1) opening of the eyes to external stimuli, (2) verbal response, and (3) motor response to stimuli. Strong evidence supports the use of urgent head CT imaging for severe TBI (based on a GCS of 3 to 8) to identify lesions requiring surgical intervention. Clinical prediction rules, such as the Canadian Head CT rule and the New Orleans criteria, derived and validated using sophisticated scientific methodology inform evidence-based imaging recommendations with CT for mild TBI. The reader is directed to the

TABLE 1.1 Glasgow Coma Scale

Eye opening	
Spontaneous	4
To voice	3
To pain	2
None	1
Verbal response	
Oriented	5
Confused	4
Inappropriate words	3
Incomprehensible words	2
None	1
Motor response	
Obeys commands	6
Localized pain	5
Withdraw (pain)	4
Flexion (pain)	3
Extension (pain)	2
None	1

original citations for details.[8,9] Tong et al. have recently summarized the available evidence guiding imaging for TBI.[10]

In the initial assessment of any trauma patient, rapid identification and stabilization of life-threatening traumatic injuries is the primary goal. Airway protection and control of bleeding are mandated during this primary survey. To control bleeding from scalp lacerations, it is sometimes necessary to staple them closed in the prehospital setting to obtain adequate hemostasis.

Identification of skull fractures increases the chance of detecting associated cervical spine injuries to 15% or more, mandating prehospital spine precautions and careful evaluation of the craniocervical junction.

Radiography

Radiographs previously played a major role in the evaluation of skull and brain lesions but now have a very limited role for the evaluation of skull fractures and are superfluous if a CT of the head has been obtained. For depiction of linear skull fractures, which may be overlooked on axial CT images, scout view images (topograms), which are included in every CT scan, can be used as a substitute for radiographs (Figs. 1.1, 1.3, and 1.4) or 3D renderings from CT (Figs. 1.2 to 1.5) can be helpful. Limited indications for skull radiographs include penetrating injuries, particularly for the course, location, and number of gunshot fragments; the location of other foreign bodies; and the presence of depressed skull fragments. In cases of suspected child abuse, skull radiographs are sometimes obtained as part of the skeletal survey for documentation or screening of injury. The absence of skull fractures on these radiographs does not reliably exclude intracranial hemorrhage.

Because of their low cost and low radiation, skull radiographs in two planes may have use in the pre-magnetic resonance imaging (MRI) screening evaluation of obtunded or unreliable trauma patients, if MRI-incompatible foreign material is suspected (e.g., ferromagnetic shrapnel).

Computed Tomography and Magnetic Resonance Imaging

CT has become the imaging modality of choice for the initial evaluation of TBI.[11] Using thin-slice multidetector CT (MDCT) acquisition with isovolumetric voxels allows for multiplanar image reconstruction (usually in the coronal and sagittal plane) in bone and brain reconstruction algorithms allowing for identification of all clinically important skull fractures.[12] Three-dimensional surface-rendered (SR) image reconstructions can be helpful and are more intuitive for clinical communication. Some data suggest increased sensitivity for fracture detection of the cranial vault and skull base with the use of curved maximum intensity projections (MIPs).[13,14] At our institution, SR image reconstruction of all head CTs of young children (<5 years) is performed to aid in the depiction of fractures and avoid the confusion of sutures with nondisplaced skull fractures (Fig. 1.2). Thin-section CT imaging is the initial

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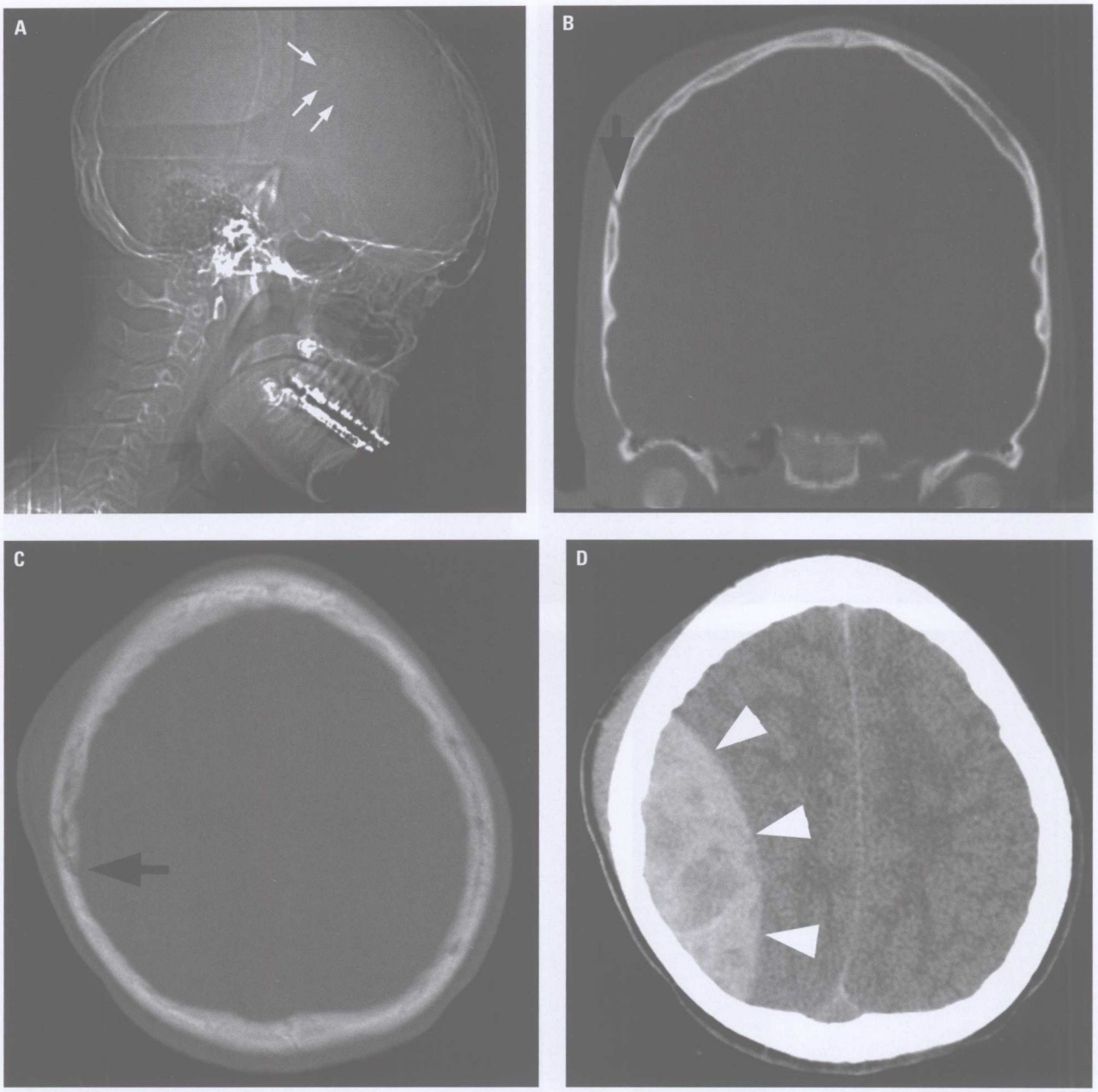

Figure 1.1. Lateral scout from CT of the head (**A**) of a 15-year-old skateboarder after a fall shows a lucent jagged line *(small white arrows)* suggestive of fracture. Coronal (**B**) and axial (**C**) CT images confirm a linear right parietal skull fracture *(black arrow)*. Brain window of the same CT (**D**) shows a large heterogeneous epidural hematoma *(arrow heads)*, which required surgical evacuation.

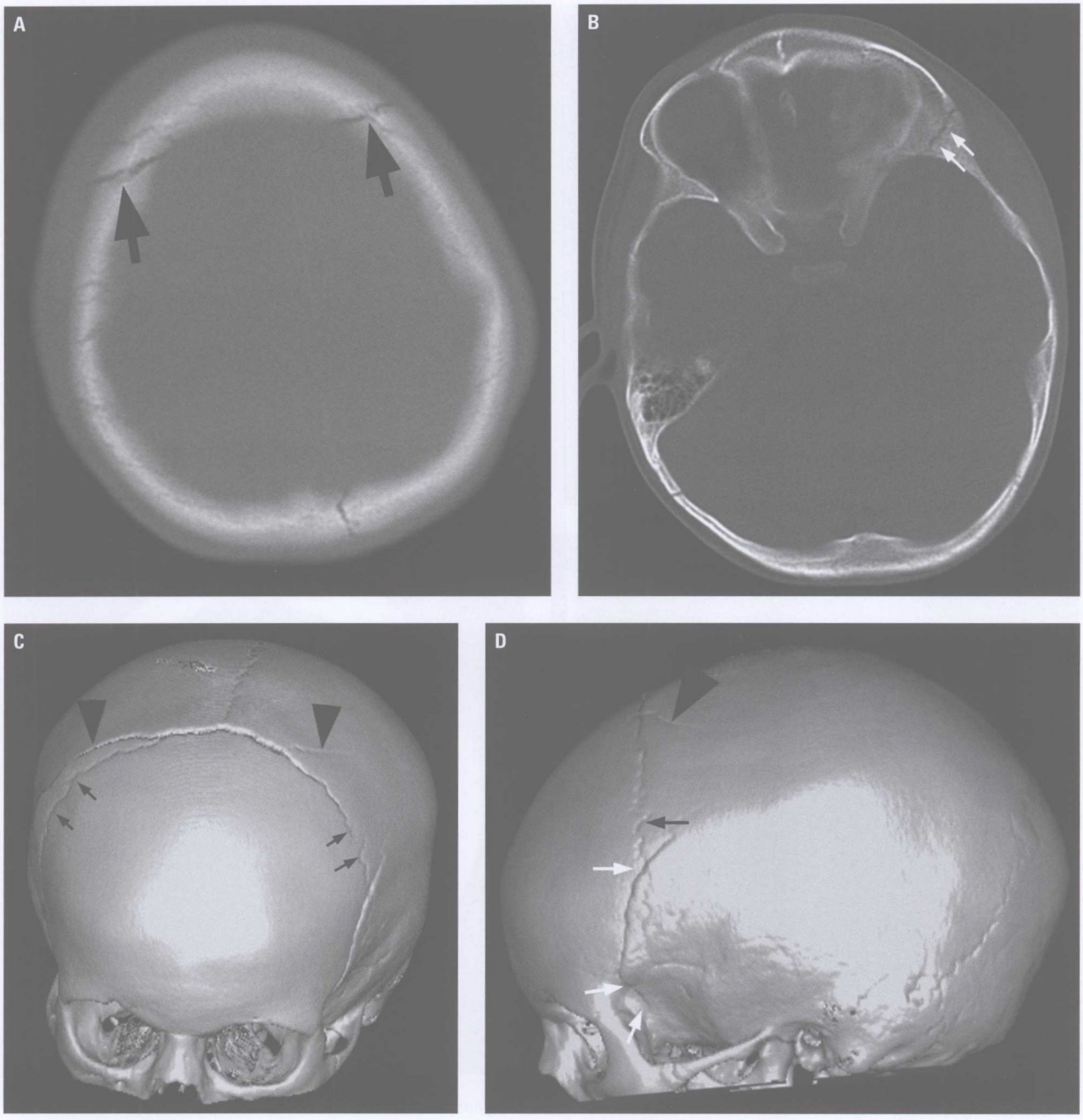

Figure 1.2. On axial CT (**A**) of a 3-year-old boy who fell 12 feet out of a window, bilateral parietal fractures *(black arrows)* could easily be mistaken for the coronal suture. Fracture extension into the sphenoid bone *(small white arrows)* is subtle on axial CT images (**B**). 3D surface renderings of the calvarium (**C**) easily allow differentiation of bilateral parietal fractures *(black arrowheads)* from the coronal suture *(small black arrows)*. Lateral 3D surface rendering (**D**) shows fracture extension across the coronal *(small black arrow)* and frontosphenoid suture into the greater wing of the left sphenoid bone *(small white arrows)*. Left high-parietal linear skull fracture is again shown *(black arrowhead)*.