ORTHOPAEDIC DECISION MAKING

BUCHOLZ-LIPPERT-WENGER-EZAKI

Orthopaedic Decision Making

ROBERT W. BUCHOLZ, M.D.

Associate Professor
Division of Orthopaedic Surgery
Southwestern Medical School
The University of Texas Health
Science Center at Dallas
Dallas, Texas

FREDERICK G. LIPPERT, III, M.D.

Associate Professor
Department of Orthopaedics
University of Washington School of Medicine
Chief, Department of Orthopaedics
Seattle Veterans Administration Hospital
Seattle, Washington

DENNIS R. WENGER, M.D.

Associate Professor
Division of Orthopaedic Surgery
Southwestern Medical School
The University of Texas Health
Science Center at Dallas
Assistant Chief of Staff
Texas Scottish Rite Hospital for Crippled Children
Dallas, Texas

MARYBETH EZAKI, M.D.

Assistant Professor
Division of Orthopaedic Surgery
Southwestern Medical School
The University of Texas Health
Science Center at Dallas
Dallas, Texas

1984

B.C. Decker Inc. • Philadelphia • Toronto
The C.V. Mosby Company • Saint Louis • Toronto • London

Publisher: **B.C. Decker Inc.**
3228 South Service Road
Burlington, Ontario L7N 3H8

B.C. Decker Inc.
Six Penn Center Plaza, Suite 305
Philadelphia, Pennsylvania 19103

North American and worldwide sales and distribution:

The C.V. Mosby Company
11830 Westline Industrial Drive
Saint Louis, Missouri 63141

In Canada: **The C.V. Mosby Company, Ltd.**
120 Melford Drive
Toronto, Ontario M1B 2X5

Orthopaedic Decision Making ISBN 0-941158-10-1

Library of Congress catalog card number: 82-83699

Last digit is print number: 10 9 8 7 6 5 4 3 2 1

PREFACE

Orthopaedic practice demands repetitive, complex decision making. Confronted with a musculoskeletal problem, the orthopaedist draws upon his understanding of basic medical and surgical principles, his experience, and familiarity with the literature to formulate a reasonable plan for diagnosis and therapy. All decisions are necessarily influenced by nonscientific considerations such as limited facilities, patient noncompliance, and financial constraints as well as the current limitations of orthopaedic science. Despite these impediments, we all strive for purism in our decision making.

Basic orthopaedic decision making is often muddled by the constant deluge of new information, recent innovations, and unfortunately, faddish techniques. This book of decision trees or algorithms may be viewed as a return to basics. Each chapter covers an orthopaedic problem which is analyzed diagrammatically, stressing the critical variables in arriving at a diagnosis or therapy. Principles and rules, not specific techniques, are emphasized. The algorithmic approach forces the reader to think systematically; even if he disagrees with the fundamental preferences of the author, the book will have served its purpose. Indeed, this educational exercise will be most valuable if it stimulates the reader to construct his own decision trees based on his experience, capabilities, and practice setting.

Four orthopaedic specialty areas, reflecting the interests and expertise of the authors, are covered: trauma, adult reconstruction, pediatric orthopaedics, and the hand. Other topics such as sports medicine, musculoskeletal oncology, and rehabilitation receive proportionately less coverage. The authors have attempted to convey the accepted standard of care but naturally, the algorithms manifest their biases to a degree. References have been carefully selected to provide a comprehensive overview of the subject.

It is hoped that this text will assist all individuals who care for patients with extremity and spinal disorders. As educators involved in university training programs, we have consciously targeted the work for residents in orthopaedics. Other medical specialists, especially general surgeons, emergency room physicians, plastic surgeons, and pediatricians, as well as general practitioners, may find this systematic approach to orthopaedics useful. It may also serve as a basis for review prior to board certification and recertification in orthopaedics.

We wish to gratefully acknowledge Cynthia Turner for her medical illustrations; Lisa Sloan, Carol Foster, and Cynthia Buchanan for their assiduous handling of secretarial duties; and Brian Decker for his seemingly endless patience with us.

Robert W. Bucholz, M.D.
Frederick G. Lippert, III, M.D.
Dennis R. Wenger, M.D.
Marybeth Ezaki, M.D.

CONTENTS

ROBERT W. BUCHOLZ, M.D.

FREDERICK G. LIPPERT, III, M.D.

CHILDREN'S ORTHOPAEDICS

DENNIS R. WENGER, M.D.

MARYBETH EZAKI, M.D.

INTRODUCTION

This text represents one of a series of books on surgical decision making. Medical educators are constantly searching for innovative and improved teaching techniques. Algorithms and decision trees, common tools employed in the business world, have been slow to appear in their application to medicine. This is an initial effort to portray diagrammatically current orthopaedic decision making. Future refinements, embellishments, and digressions will be required, as diagnostic and therapeutic modalities increase in sophistication and the science of orthopaedic surgery advances.

Each chapter is presented as an algorithm. The algorithmic heading may be a patient's symptom (the "sprained ankle", heel pain, febrile child with limb pain, altered sensation in the hand) or a musculoskeletal sign (knee instability, chronic knee effusion, toeing in and out in the child). The resultant algorithm cascades down through additional pertinent history, physical findings, and laboratory examinations to end in a differential diagnosis. Therapeutic algorithms, alternatively, commence with a given diagnosis (acromioclavicular dislocation, degenerative arthritis of the hip, slipped capital femoral epiphysis, bite wounds) and flow through variables which influence decisions on therapy. Most trauma algorithms, as would be expected, fall into this latter group, while the reconstructive, pediatric, and hand decision trees furnish a mix of diagnostic and therapeutic problems.

The algorithms are structured so that they may be used independently of the comments. The headings at each branch are self-explanatory with specific treatment recommendations enclosed in boxes. Tangential loops along branches are intended to remind the reader of common variants in a given decision. The comments clarify and expand the information in the algorithm. Distinctions, guidelines, and exceptions to rules, not to be viewed as hedging, are offered in the comments. The bibliography is selected to both substantiate critical branches in the decision tree and provide the reader with sources of the detailed information. Use of the listed references is strongly encouraged.

PRINCIPLES OF FRACTURE MANAGEMENT

COMMENTS

A. All life-threatening injuries take precedence over any fracture or dislocation. Resuscitative measures aimed at monitoring and stabilizing vital signs should be performed on an emergency basis. Hemorrhage into fracture sites and surrounding soft tissues may exceed 2 units in closed femoral fractures, and 7 to 8 units after unstable pelvic fractures. Blood loss secondary to open fractures is unpredictable.

B. The status of the soft tissues profoundly influences the ideal treatment of any fracture. The extremity must be inspected circumferentially to reveal any break in the skin. Distal neurovascular function should be carefully documented with any abnormalities appropriately evaluated. Occult injuries to the adjacent joints are best detected by physical examination. Splint the extremity in neutral position. Manipulative realignment of the limb prior to diagnostic radiographs is only warranted if there is severe neurovascular compromise from an angulated fracture.

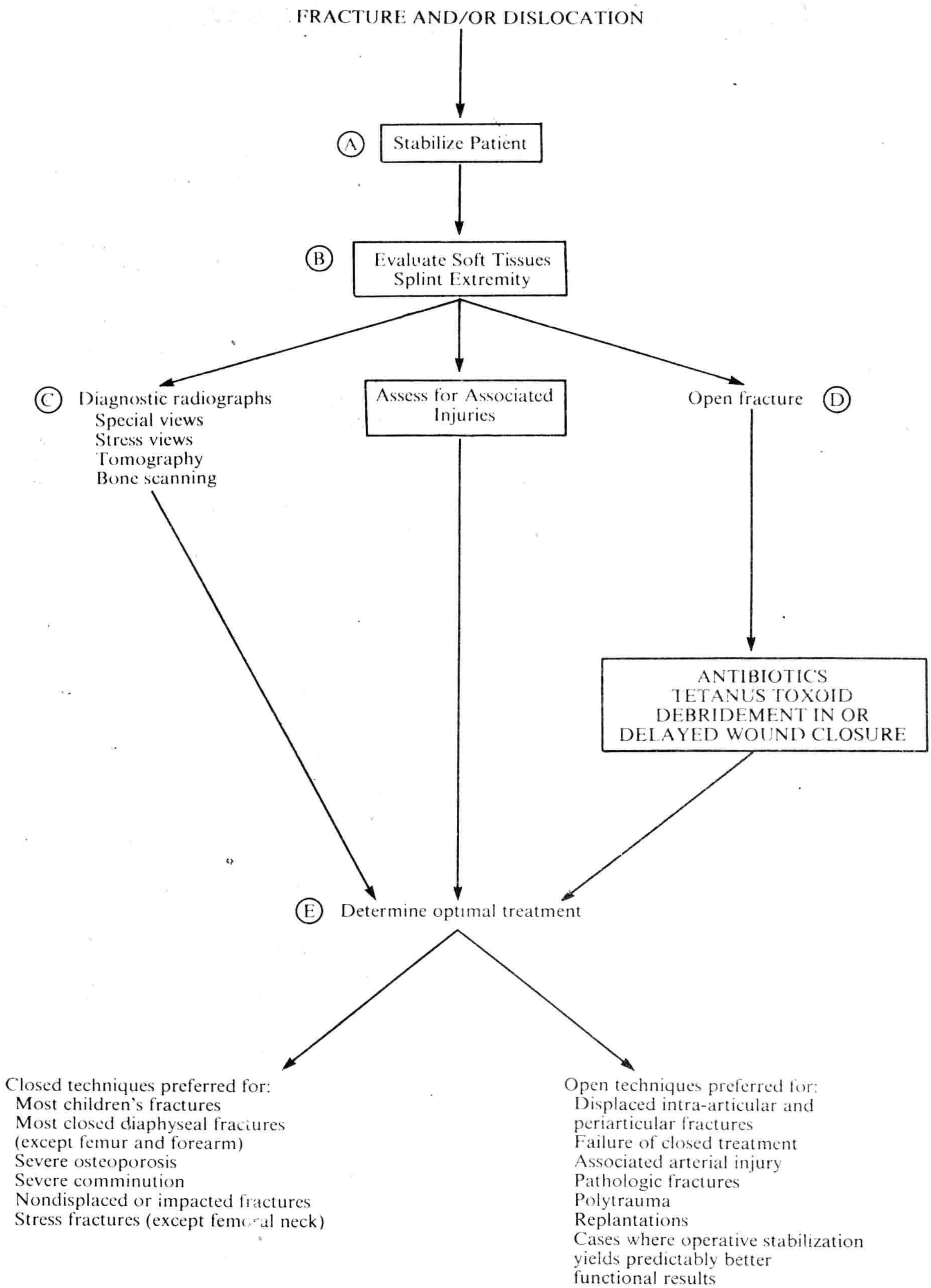
C. The key to accurate diagnosis is correlation of the radiographs with the physical findings. The treating physician, not the radiologist, is thus responsible for the definitive diagnosis. Special, nonstandard radiographic views such as obliques, stress views, and tomographs aid in clarifying equivocal cases. Stress fractures may be diagnosed early with scintigraphy.

D. All open fractures should be treated aggressively. Broad spectrum antibiotics, generally a cephalosporin, should be administered as early as possible. Thorough debridement in the operating room is mandatory. The presence of gross contamination or major soft tissue defects may alter the ideal treatment of a given fracture.

E. Controversy surrounds what constitutes the preferred treatment of many fractures. With the advent of new techniques and implants, fracture care is a rapidly evolving art.[1,2,3] Therefore, the algorithms which follow necessarily reflect the current preference of the author.

REFERENCES

1. Rockwood C, Green D. Fractures. Philadelphia. JB Lippincott, 1975.
2. Muller M, Allgower M, Schneider R, Willenegger H. *Manual of Internal Fixation*. Berlin: Springer-Verlag, 2nd edition, 1979.
3. Mears D. External Skeletal Fixation. Baltimore: Williams & Wilkins, 1983.


FRACTURE AND/OR DISLOCATION
(A) Stabilize Patient
(B) Evaluate Soft Tissues
Splint Extremity
(C) Diagnostic radiographs
Special views
Stress views
Tomography
Bone scanning
Assess for Associated Injuries
Open fracture (D)
ANTIBIOTICS
TETANUS TOXOID
DEBRIDEMENT IN OR
DELAYED WOUND CLOSURE
(E) Determine optimal treatment
Closed techniques preferred for:
Most children's fractures
Most closed diaphyseal fractures
(except femur and forearm)
Severe osteoporosis
Severe comminution
Nondisplaced or impacted fractures
Stress fractures (except femoral neck)
Open techniques preferred for:
Displaced intra-articular and
periarticular fractures
Failure of closed treatment
Associated arterial injury
Pathologic fractures
Polytrauma
Replantations
Cases where operative stabilization
yields predictably better
functional results

FRACTURE OF THE ATLANTOAXIAL COMPLEX

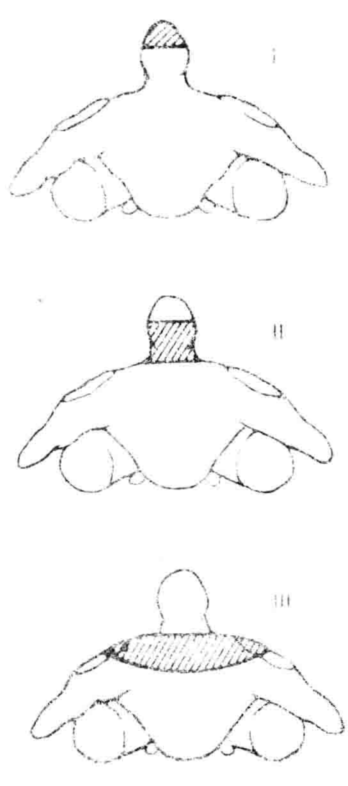
COMMENTS

A. The radiographic signs of atlantoaxial injuries are often subtle. The prevertebral soft tissue shadow on the lateral radiograph should be less than 5 mm wide at C2 and 10 mm wide in front of the ring of the atlas. Localized increases in the soft tissue shadow width may signify an occult fracture or subluxation.

B. Polytomography is rarely indicated in the routine evaluation of atlantoaxial injuries. Occasionally the detection and categorization of nondisplaced odontoid fractures necessitates its use.

C. CT scans are especially helpful in identifying and evaluating Jefferson fractures and atlantoaxial rotatory subluxation.

D. Spreading of the lateral masses of the atlas of greater than 7 mm on the open-mouth odontoid view indicates probable transverse ligament disruption.[1]



Anderson D'Alonzo classification of odontoid fractures

E. Healing of the various components of a Jefferson fracture can be evaluated by CT scanning. The status of the transverse ligament is determined by lateral flexion-extension radiographs.[2] Nonunion of either the anterior ring or posterior ring fractures associated with transverse ligament disruption may require special fusion constructs to restore upper cervical spine stability.[3]

F. The Anderson-D'Alonzo classification (see figure) of odontoid fractures is useful in predicting the likelihood of fracture union with nonoperative treatment.[4] Type III fractures extend into the cancellous bone of the axis and have an excellent prognosis with adequate external immobilization. Type II fractures through the body or base of the odontoid have an incidence of nonunion reported at between 30 and 60%.

G. Controversy surrounds the ideal treatment of type II odontoid fractures.[5] Such variables as patient age, fracture obliquity and displacement, associated injuries, and patient preference must be considered.

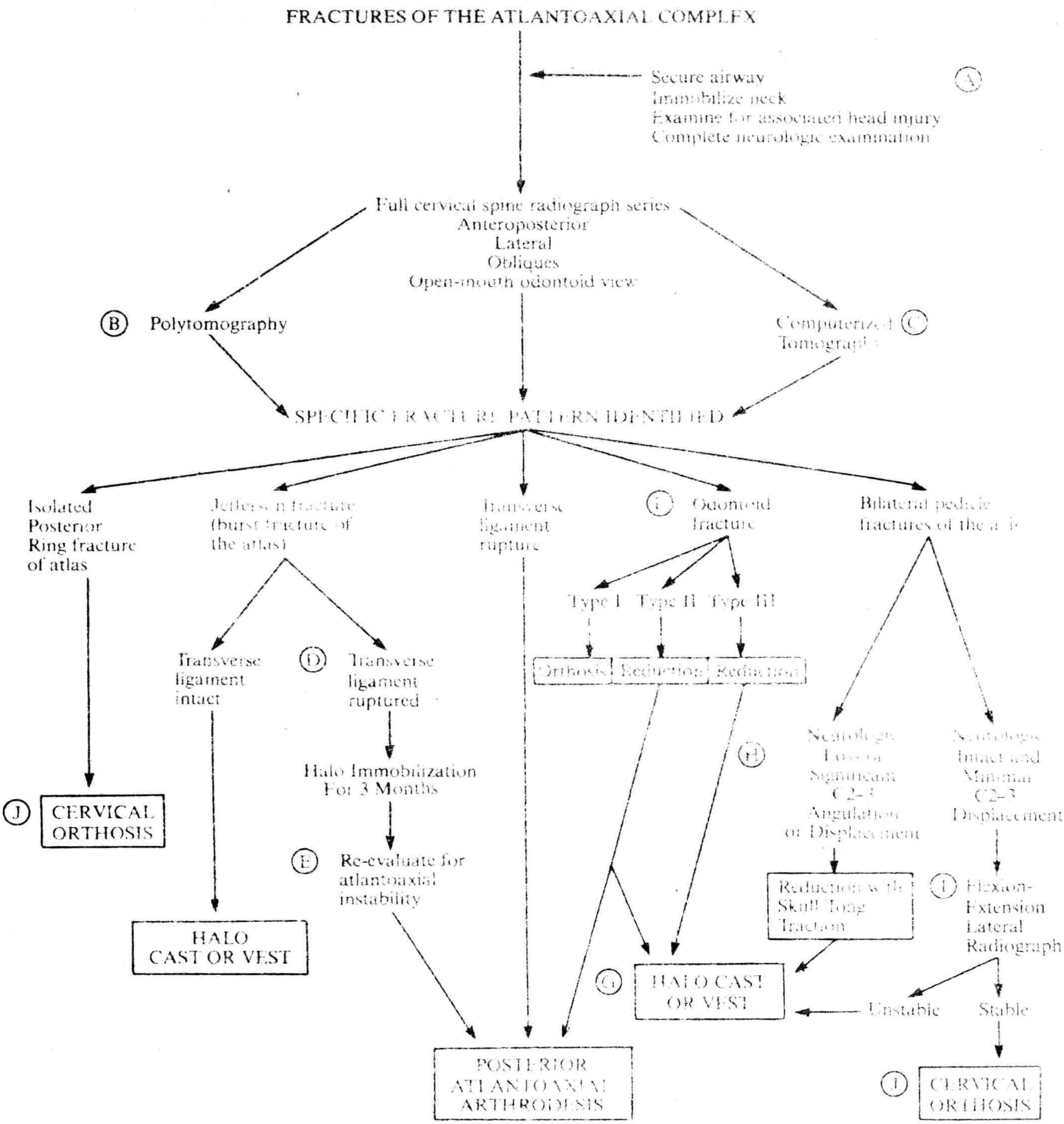
H. Bilateral pedicle fractures of the axis (hangman's fracture, traumatic spondylolisthesis of the axis) are usually associated with variable injury to the C2–C3 interspace anteriorly and the atlantoaxial membrane posteriorly. Interruption of the posterior longitudinal ligament allows significant horizontal translation of the cervicocranium on C3, resulting in neurologic damage.[6]

I. Absolute prerequisites for obtaining flexion-extension radiographs include: (1) absence of any demonstrable neurologic deficit, (2) absence of an altered state of consciousness, including intoxication, and (3) ability of the patient to actively flex and extend his neck without assistance. If adequate flexion-extension views are unobtainable, the fracture must be managed as a potentially unstable lesion.[7]

J. Only intermediate class orthoses (e.g., Yale brace, somi-brace, four-poster brace, or cervicothoracic orthosis) should be used. Soft cervical collars provide insufficient immobilization of the neck.

REFERENCES

1. Spence K, Decker S, Seil K. Bursting atlantal fracture associated with rupture of the transverse ligament. J Bone Joint Surg. 1970; 52A:543.
2. Fielding J, Van Cochran G, Lawsing J, Hohl M. Tears of the transverse ligament of the atlas. J Bone Joint Surg. 1974; 56A:1683.

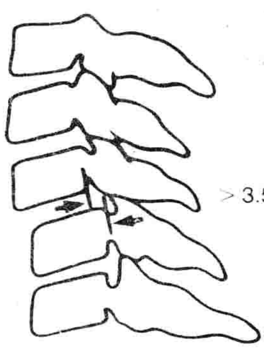


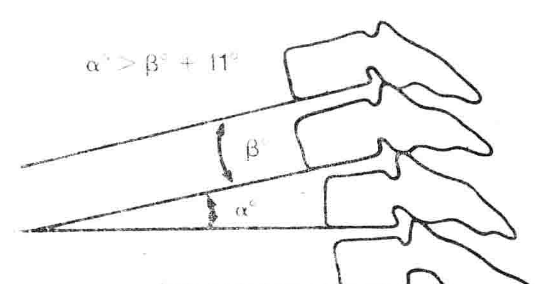
3. Sehlke E, Callahan R. A rational approach to burst fractures of the atlas. Clin Orthop Rel Res. 1981; 154:18.
4. Anderson L, D'Alonzo R. Fractures of the odontoid process of the axis. J Bone Joint Surg. 1974; 56A:1663.
5. Southwick W. Management of fractures of the dens. J Bone Joint Surg. 1980; 62A:482.
6. Bucholz R. Unstable hangman's fractures. Clin Orthop Rel Res. 1981; 154:119.
7. Brashear H, Venters G, Preston E. Fractures of the neural arch of the axis. J Bone Joint Surg. 1975; 57A:879.
8. Johnson R, Hart D, Simmons F, Ramsby G, Southwick W. Cervical orthoses—study comparing their effectiveness in restricting cervical motion in normal subjects. J Bone Joint Surg. 1977; 59A:332.

LOWER CERVICAL SPINE FRACTURE OR DISLOCATION

COMMENTS

A. All polytrauma patients with altered states of consciousness and all patients with pain or point tenderness in the neck warrant a diagnosis of possible cervical spine fracture or dislocation. If the emergency cross-table lateral radiograph is normal or equivocal, a full cervical spine series is required. The entire cervical spine from the occiput to C7 must be adequately visualized on lateral radiographs, often necessitating a swimmers view of the cervicothoracic junction. Elective cervical tomography assists in detecting fractures of the pedicles, lamina, and facet joints. As in upper cervical spine injuries, the absolute prerequisites for flexion-extension radiographs include an unaltered mental status, the absence of any neurologic symptoms or signs, and the capability of the patient to flex and extend actively without any manipulation by the physician. Occult ligamentous injuries may be disclosed by flexion-extension views, which are mainly indicated in cases of presumptive stable fracture patterns.





Criteria for lower cervical spine instability.

B. An unstable cervical spine injury is one in which there is sufficient osseous or ligamentous disruption so that under physiologic loads, displacement of the spinal elements results in nerve root or spinal cord damage. Quantitative measures of spine stability are imprecise. Generally, either a horizontal translation of greater than 3.5 mm of one vertebral body on an adjacent vertebra or an angulation between two vertebrae of 11° more than contiguous vertebra implies probable instability.[1] All cervical spine fractures should be presumed unstable until definitively proved otherwise.

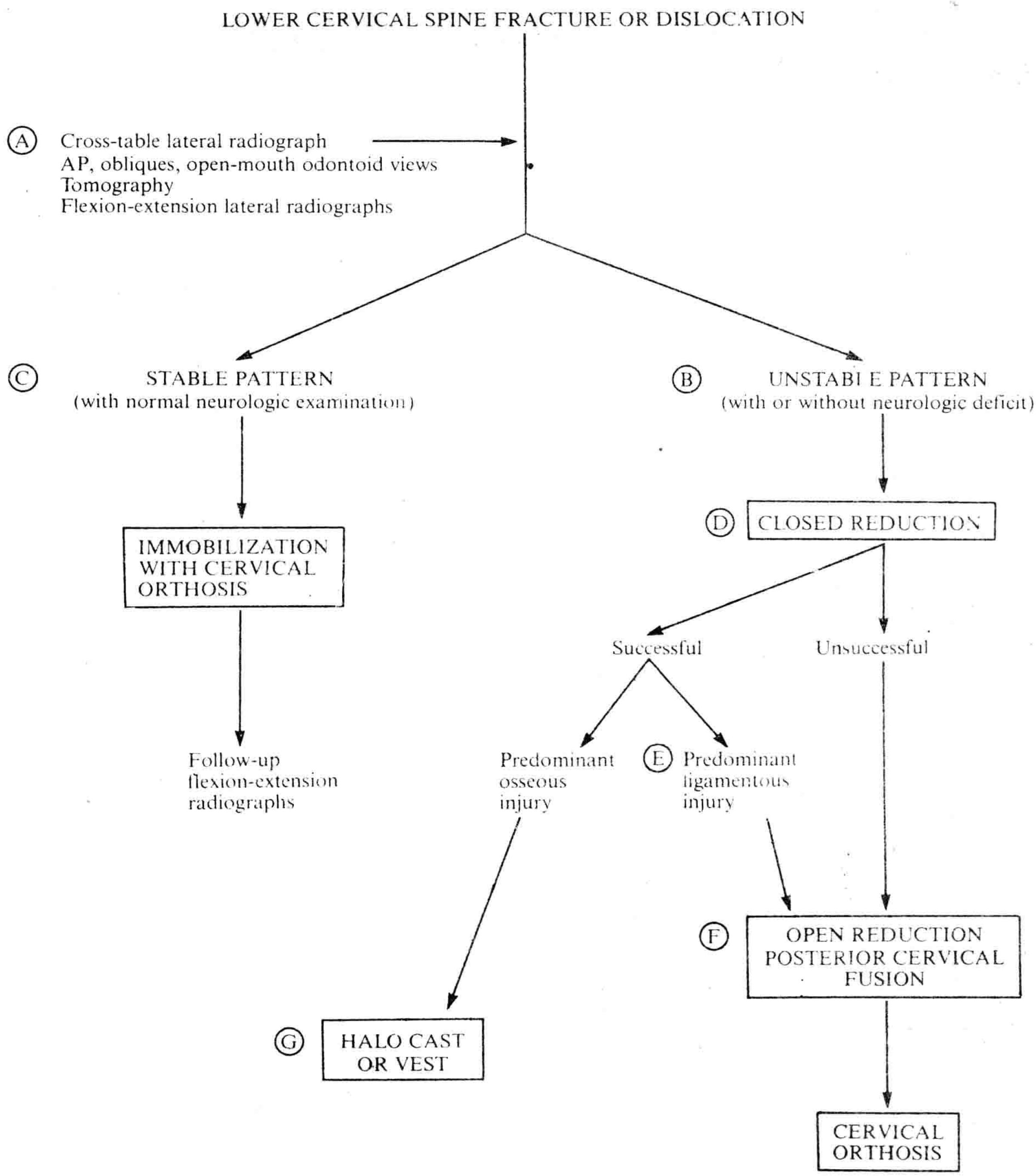
C. Stable patterns include isolated compression fractures of the vertebral body, lateral mass fractures, spinous process fractures, and most fractures secondary to penetrating neck trauma. Cervical pain and muscular spasm may prevent adequate flexion and extension during diagnostic radiographs. Follow-up flexion-extension radiographs are thus required to rule out unsuspected ligamentous injuries.

D. With careful monitoring of neurologic symptoms and signs, closed reduction is attempted with skull tong traction, occasionally supplemented with manual manipulation under radiographic control. All cases with demonstrable neurologic loss or grossly unstable fracture patterns need emergency closed reduction. The required traction weight, ranging up to 35 lb for C7–T1 dislocations, varies with the fracture level.[2]

E. The inconsistent healing of posterior ligamentous tears gives rise to a high incidence of chronic spinal instability.

F. The posterior surgical approach is preferred in nearly all cases necessitating open reduction or fusion, or both. It permits reduction of jumped facets under direct visualization, provides a more rigid fusion construct, and minimizes further surgical compromise of the supporting spinal structures.

G. Major osseous injuries generally heal without the need for surgical fusion. Satisfactory alignment during healing can be achieved with traction or halo immobilization. Prolonged traction treatment is the less attractive alternative because of the complications of bed rest, the need for lengthy hospitalization, and the delays in commencing rehabilitation of the patient with spinal cord injury. If properly utilized, the halo device provides sufficient stabilization in most cases for early mobilization of the patient.[3]



REFERENCES

1. White A, Johnson R, Panjabi M, Southwick W. Biomechanical analysis of clinical stability in the cervical spine. Clin Orthop Rel Res. 1975; 109:85–96.
2. Johnson R, Southwick W. Surgical approaches to the spine. In *The Spine*. Rothman R, Simeone F, eds. Philadelphia, WB Saunders. 1975; 1:69-132.
3. Nickel V, Perry J, Garrett A, Heppenstall M. The halo-A spinal skeletal traction device. J Bone Joint Surg. 1968; 50A:1400.

THORACOLUMBAR FRACTURE AND DISLOCATION

COMMENTS

A. Hyperflexion forces cause most thoracolumbar injuries, approximately half of which occur at the thoracolumbar junction. All resuscitative and diagnostic measures performed prior to and during radiography of the spine must be done with the patient immobilized in a supine position. Plain AP and lateral radiographs are often of poor quality and fail to visualize adequately all spinal elements. CT scanning has replaced polytomography as the best adjunctive test for defining spinal pathology.

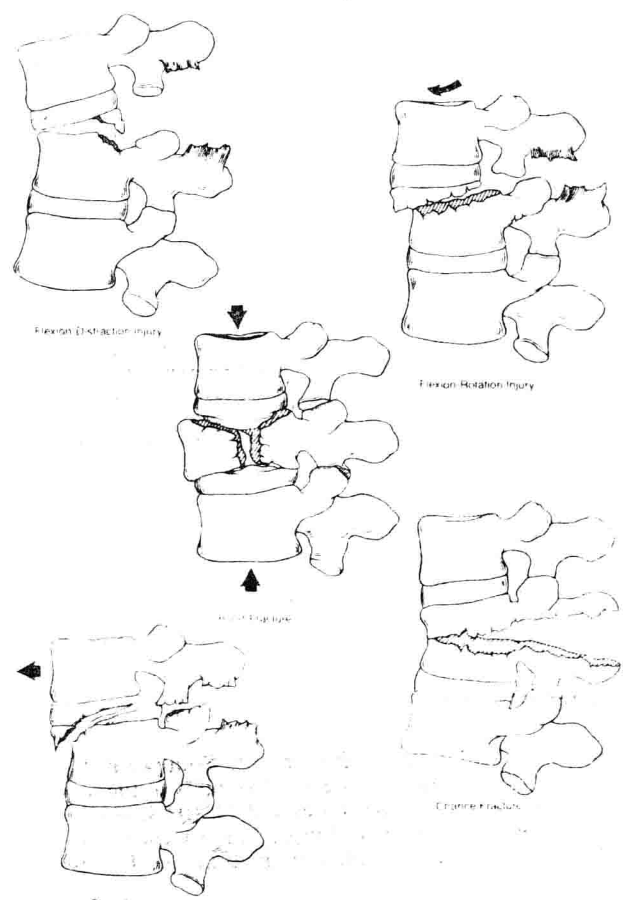
B. Nearly all major thoracolumbar injuries result in a vertebral body fracture. The concomitant posterior element injury is usually trivial, often merely a ligamentous sprain. If there is sufficient posterior osseous or ligamentous disruption to permit significant spinal displacement with real or potential neurologic compromise, the injury is defined as unstable.[1] Unless there is gross spinal angulation or translation on the diagnostic radiographs or a presenting neurologic deficit, instability may be difficult to verify. CT scanning helps, but no quantitative guidelines for stability are universally accepted. Most classification schemes are based on mechanisms of injury.[2] Stable injuries generally include isolated compression and wedge fractures of the vertebral body, rare hyperextension injuries such as traumatic spondylolisthesis, and transverse or spinous process fractures secondary to direct trauma or muscular contractions. Major flexion-distraction, flexion-rotation, burst (axial load), and shear forces lead to unstable fracture patterns.

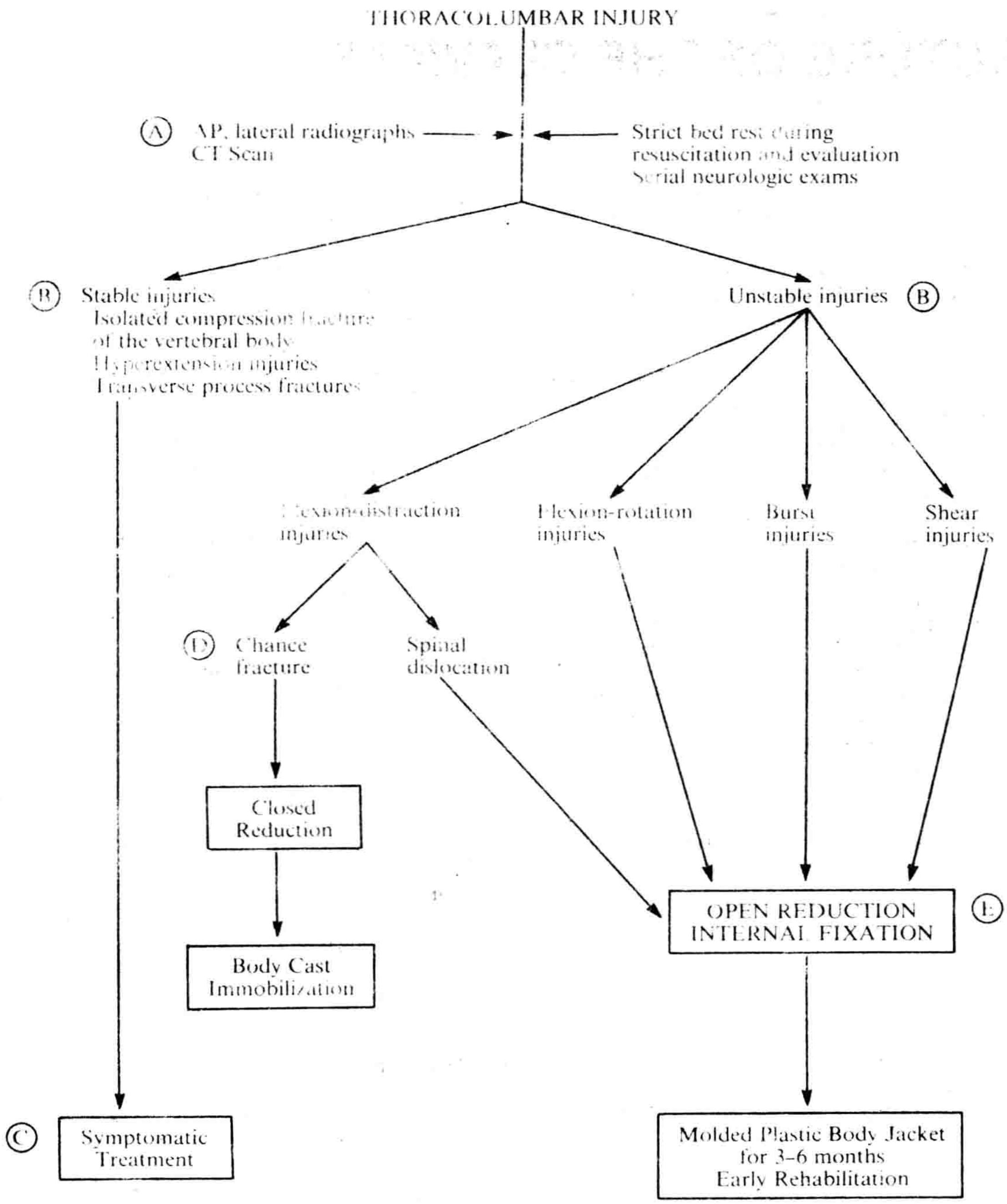
C. No conventional orthoses provide firm immobilization of the thoracolumbar spine. After a short period of bed rest, symptomatic relief of pain from stable fractures can however be achieved with corsets or spinal braces e.g., Knight-Taylor or Jewett.

D. Flexion-distraction forces to the spine, often experienced by persons wearing lap seat belts during a traffic accident, can cause transverse fractures through both anterior and posterior spinal elements (Chance fracture). Due to the broad cancellous fracture surfaces, these fractures, which commonly occur in the upper or midlumbar region, heal readily and are not prone to late instability.

E. Spinal cord injury with unstable thoracolumbar fracture-dislocations can result from cord compression (burst fractures), cord crushing (flexion-rotation and shear fractures), or cord traction (flexion-distraction dislocations). Decompression of the neural elements is best accomplished by realignment and stabilization of the spine. Open reduction and internal fixation with Harrington instrumentation are preferred to closed techniques, since improved fracture reduction, early patient mobilization and rehabilitation, and decreased hospitalization are usually realized.[3] Laminectomy should be limited to those rare cases with a well-documented progressive neurologic loss. Reduction or extraction of retropulsed posterior body fragments from the neural canal commonly seen in burst fractures can be done through either an anterior or posterolateral approach, depending upon the experience of the surgeon.

The timing of operative treatment and the role of routine spinal arthrodesis remain controversial. In general, unstable patterns with a partial neurologic deficit should be reduced and stabilized immediately, whereas those with no neural deficit or a complete lesion can be surgically stabilized on an elective basis. Bone grafting and fusion are mainly indicated in paraplegic patients and patients with pure ligamentous injuries.





REFERENCES

1. Kelly R, Whitesides T. Treatment of lumbodorsal fracture-dislocations. Ann Surg. 1968; 167:705.
2. Holdsworth F. Fractures, dislocations and fracture-dislocations of the spine. J Bone Joint Surg. 1970; 52A:1534.
3. Dickson J, Harrington P, Erwin W. Results of reduction and stabilization of the severely fractured thoracic and lumbar spine. J Bone Joint Surg. 1978; 60A:799.