CLASSIFICATION

OF GUNSHOT WOUNDS OF SKULL AND CEREBRUM

Classification of gunshot wounds of skull and cerebrum

edited by:

Y. H. Pedachenko Doctor of medical sciences, professor, head of The State Institution Romodanov Neurosurgery Institute National Academy of Medical Sciences of Ukraine, academician of National Academy of Medical Sciences of Ukraine

Andre Grotenhuis, M.D., Ph.D. Professor of Neurosurgery, Radboud University Medical Centre, Nijmegen, The Netherlands Immediate Past-President, European Association of Neurosurgical Societies

Classification of gunshot wounds of the skull and cerebrum. Tutorial

ISBN: 978-966-1543-56-9

The tutorial is intended for students of the Ukrainian Military Medical Academy, senior medical students, postgraduate neurosurgery students, military and civilian neurosurgeons, general military surgeons, who must have skills of providing surgical assistance in case of combat gunshot trauma of the skull and cerebrum. The manual will be useful for the work of forensic medical experts, as well as for the unification of the scientific and statistical analysis of the gunshot wounds of the skull and cerebrum.

Introduction

The Ukrainian Red Cross always fulfills the mission of reducing the humanitarian crisis during emergencies, because every life matters.

The events taking place in Ukraine impacts on the operation of the entire International Movement Red Cross and Red Crescent. In addition to timely evacuation of people, provision of humanitarian aid, and first aid training, we also see our mission in optimizing the provision of medical care to victims of war.

Medical care is based on understanding the processes arising from injuries, thus the Ukrainian Red Cross presents to the International Red Cross movement a modern classification of cranial and brain gunshot wounds. This classification enables the assessment of the nature of the injury, determination of aid principles, surgical tactics, and prediction of consequences.

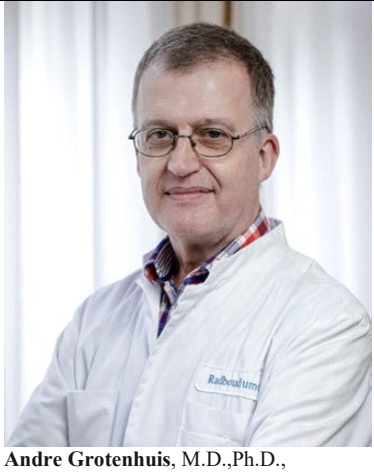
The authors, leading neurosurgeons of Ukraine, presented their own observations that may be useful for the work and education of specialists.

The Ukrainian Red Cross considers it their duty to disseminate the acquired experience to the general public.

Director General of the National Committee of the Ukrainian Red Cross Society
Maksym Dotsenko

FROM EDITORS

E.G. Pedachenko Doctor of Medical Sciences, professor Head of the Institute of Neurosurgery named after acad. A.P. Romodanov NAMS of Ukraine Academician of the National Academy of Sciences of Ukraine



Andre Grotenhuis, M.D.,Ph.D., Professor of Neurosurgery, Radboud University MedicalCentre, Nijmegen, The Netherlands

This tutorial is a joint analytical scientific and practical work of the Neurosurgery Clinic of the National Military Medical Clinical Center "Main Military Clinical Hospital of the Ministry of Defense of Ukraine" and the Department of Neurosurgery of the National Medical Academy of Postgraduate Education named after P.L. Shupyk.

Using their own scientific material, the authors have developed a modern classification of gunshot cranio-cerebral wounds based on the results of treatment of this severe neuropsychiatric pathology in 665 servicemen of the Armed Forces of Ukraine - wounded in the current military conflict in eastern Ukraine.

The lowest rates of mortality and infectious complications of gunshot craniocerebral wounds, received by the authors from the first days of April 2014 during everyday treatment of wounded servicemen, testify to the high level of training and provision of the specialized neurosurgical assistance by the military neurosurgeons of Ukraine.

The principle of classification of gunshot craniocerebral wounds, taken into account in the daily practice of treatment of 354 penetrating and non-penetrating wounds and 311 wounds of the soft tissues of the skull's arches, proposed by the authors, has no analogues among modern world scientific reports.

We hope that the clinical computer-tomographic classification of gunshot craniocerebral wounds, created by the authors, will help further studies of this extremely traumatic pathology of the central nervous system, will boost the results of its treatment and will take a worthy place in improvement of the traditional classification adopted in the countries The European Union.

MAIN MILITARY AND MEDICAL ADMINISTRATION

NATIONAL MILITARY CLINICAL CENTER "GVKG"

UKRAINIAN MILITARY MEDICAL ACADEMY

NATIONAL MEDICAL ACADEMY OF POST-GRADUATE EDUCATION
NAMED AFTER P.L. SHUPYK

CLASSIFICATION OF GUNSHOT WOUNDS OF SKULL AND CEREBRUM

Tutorial

Approved as a tutorial by the protocol of the Academic Council of the Ukrainian Military Medical Academy dated August 29, 2017, No. 191 and the protocol of the Academic Council of the National Medical Academy of Postgraduate Education named after PL. Shupyk dated September 13, 2017, № 7

KYIV-2018

CONTENTS

Introduction 7

Chapter 1
General classification of firearms
injury to the skull and brain.
Terminology 15

Chapter 2
Gunshot wounds of soft tissues of the skull's arches. 18

Chapter 3
Gunshot non-penetrating wounds of skull and cerebrum 33

Chapter 4
Gunshot penetrating wounds of skull and cerebrum. 44

INTRODUCTION

This tutorial is the result of scientific and practical analysis of personal observations of the wounded who take part in military actions in Antiterrorist operation in the east of Ukraine and are based on the study of the organization of medical aid, clinic peculiarities, diagnosis and treatment of patients with gunshot wounds of skull and cerebrum in the system of treatment and evacuation support of the Armed Forces of Ukraine. The authors have studied scientific and practical experience of military medicine in the Second World War and data from literary sources on gunshot craniocerebral wounds in various local wars and military conflicts of the current century.

Classification is a systematic distribution of anything by class according to evident features. Classification of gunshot wounds of skull and cerebrum is a system in which significant signs of wounds are distributed by the groups of homogeneous manifestations of etiology, mechanisms of wounds, character, localization of anatomical lesions, according to clinical and X-ray (radiological) characteristics, pathophysiological changes of skull and cerebrum in order to determine the exact clinical diagnosis and the choice of the correct tactics of medical care in the treatment and evacuation support of the Armed Forces of Ukraine.

Analysis of the results of medical care provided in cases of traumas of skull and cerebrum received in the Antiterrorist operation zone in the east of Ukraine proves the need for a single, understandable and simple, modern classification of gunshot wounds of skull and cerebrum for:

- unification of the clinical expert diagnosis;
- assessment of the severity of the condition of the wounded;
- optimization of the process of sorting of the wounded at the stages of medical evacuation;
- determination of the priority of the evacuation destination;
- development of treatment tactics and standards;
- creation of forecasting algorithms;
- comprehensive substantiation of scientific data and formation of the foundations of scientific, promising researches;
- organization of necessary statistical records.

Basic provisions of modern classifications of gunshot wounds of skull and cerebrum have been developed more than a hundred years ago.

Long before the First World War O.M. Holberg based on the experience of Russian-Japanese War (1904-1905) in 1911 published a monograph "On Military Field Wounds of the Skull", in which he classified the gunshot craniocerebral wounds into blind, tangent, segmental and diametrical. At the heart of the classification of the gunshot trauma of the skull and cerebrum lie three large groups of wounds, proposed by I.I. Petrov in 1917: wounds of the soft tissues of the skull's arches, not penetrating and penetrating wounds. Subsequently, the classification was improved and supplemented. During the Second World War, it was supplemented by the classification of the types of gunshot fractures of the skull bones, proposed by M.S. Kosinskaya in 1941. At that time, the diagnosis was based on the clinical manifestations of the gunshot wounds of skull and cerebrum, as well as on radiography and anatomical and physiological data.

This traditional clinical-X-ray anatomical classification of gunshot wounds of the skull and cerebrum has not practically changed until nowadays. It is the basis of diagnosis formulation and development of the general system of provision of specialized neurosurgical assistance in post-Soviet countries and many western countries, including countries of the North Atlantic Alliance in various modifications. A single generally accepted classification of the gunshot wounds of skull and cerebrum is still nonexistent.

The traditional classification reflects the nature of pathological changes in cases of gunshot wounds of skull and cerebrum. But it has a significant drawback in the evaluation of pathoanatomical changes of cerebrum, particularly, in penetrating wounds. With the diagnosis formulated according to it there is a quite vague picture of cerebrum wound itself left, its anatomic and pathological essence. After all, brain damage determines the gravity of the wounded condition, the prognosis and the result, which is difficult to determine not only for young neurosurgeons, but for experienced specialists as well. There is no clear definition of wound channel and methodological recommendations as to how to use it correctly in the classification. Formulation of the expanded diagnosis still presents some difficulties for the doctor. In the traditional classification all gunshot wounds of the skull are distributed according to the localization of the anatomical areas of the skull (namely, the skull, not the cerebrum), but by localization, parts of the cerebrum do not completely topographically coincide with the areas of the bones of the skull. In the traditional classification brain damage are not allocated so

clearly and precisely, as in the classification of mechanical wounds of skull and cerebrum.

More than 70 years have passed since the Second World War. A lot has changed, particularly two main factors, that play an important role in the gunshot craniocerebral wounds. There are new types of weapons with wounding projectiles with huge kinetic energy that grave devastating consequences for the human body. Highly informative methods of research of the pathology of skull and cerebrum were created, such as computer and magnetic resonance tomography, that allow us to determine the nature of the damage to the skull and cerebrum, to identify many factors and peculiarities necessary for optimization of surgical intervention, to determine the exact localization of pathological changes. This allows us to optimize the planning of the execution of a complex operation - the primary surgical treatment of the craniocerebral wound, based on which the success of the treatment of the wounded depends greatly.

As personal experience of treatment of gunshot war wounds of skull and cerebrum was growing, the necessity of systematization of the gathered data taking into account modern radiological methods of research appeared and we decided to offer a simple, easy-to-use classification that reflects the main features of the gunshot wounds of skull and cerebrum. This allowed us to transform the traditional clinical X-ray anatomical classification of gunshot wounds of skull and cerebrum into modern clinic CT anatomical classification, taking into account the understanding that the main anatomical-pathological substrate, which causes the severity of the condition of the wounded and his prospects for recovery from the gunshot penetrating craniocerebral wounds, is brain damage, that is traditionally called wound channel. Particular attention is given to the description of the wound channel by localization and size in fractions of the brain according to CT data (computed tomography) in a diagnosis. In cases of non-penetrating wounds particular attention is paid to pathological changes in the brain, as well as in cases of gunshot wounds of soft tissues of the skull's arches, which are accompanied by internal cerebral traumatic changes. Modern CT and MRI (Magnetic resonance imaging) research methods have revealed new perspectives in diagnostics of the exact localization of the damages of soft tissues of the skull arches, skull bones, brain substance and its structures, bone fragments and their

number, the removal of which is one of the most important factors in prevention of infectious complications.

Based on our own experience of treatment of 665 military personnel with gunshot craniocerebral wounds, which amounted to more than 20% of all military traumas in the current military conflict – Antiterrorist operation in the eastern part of Ukraine, we came to the conclusion: two main indicators of the results of treatment of penetrating and non-penetrating gunshot wounds of the skull and cerebrum - lethality and infectious complications are the lowest in the Armed Forces of Ukraine in comparison with the results of treatment of similar wounded in other local wars in the world (Table 1).

The obtained data testify to the high level of professional training of military and civil neurosurgeons who provide specialized neurosurgical assistance to the wounded in the Armed Forces of Ukraine.

Table 1.

THE RESULTS OF NEUROSURGICAL AID IN SEVERE GUNSHOT WOUNDS OF SKULL AND CEREBRUM IN SOME LOCAL WARS AND ARMED CONFLICTS AFTER THE SECOND HALF OF 20 CENTURY					
Local wars and armed conflicts		Absolute number of gunshot wounds of skull and cerebrum		The frequency of infectious rate, complications, %	Fatality
Korean War	1950-1953	United States Army	163	51 ->10	29 ->8
Vietnam War	1968	Armed Forces of Vietnam	No data	70	68
Vietnam War	1968	United States Army	294	32	16
War conflict in Afghanistan	1979-1989	USSR Army	No data	100 -> 35	38 -> 27
Iran-Iraq War	1980-1988	Armed Forces of Iran	203	14,3	23
Iran-Iraq War	1980-1988	Armed Forces of Iraq	161	6	13
Yugoslav War	1993		217	8	No data
Chechnya War (RF)	1994-1996	Armed Forces of Russia	161	37	24
Second Chechen War	1999-2002	Armed Forces of Russia	294	29	16
War in Afghanistan	2001-2010	United Armed Forces of NATO	215	No data	No data
Antiterrorist operation on the east of Ukraine	2014-2017	Armed Forces of Ukraine	354	5,9	11,6

Accumulated experience in providing medical care to the wounded in the areas of skull and cerebrum in the system of treatment and evacuation support and positive treatment results allowed us to improve the classification of craniocerebral wounds for an accessible understanding of all aspects of complex diagnostic process and improvement of results of treatment of the wounded.

For the reader to understand the material of classification of gunshot wounds of the skull and cerebrum the illustrations were used, on the basis of which this manual is developed.

Figure 1 presents the work of art of Mark Lithgow and Chloe Hatton (2004) «Enlarged tomogram of the head» - a picture painted in such a way, so that the brain and spinal cord (green and blue colors on the illustration) stand out against the background of other tissues (pink, red and other colors on the illustration). Schematically shown (pic. 1-b) subdural spaces, skull and soft tissues of skull covers.

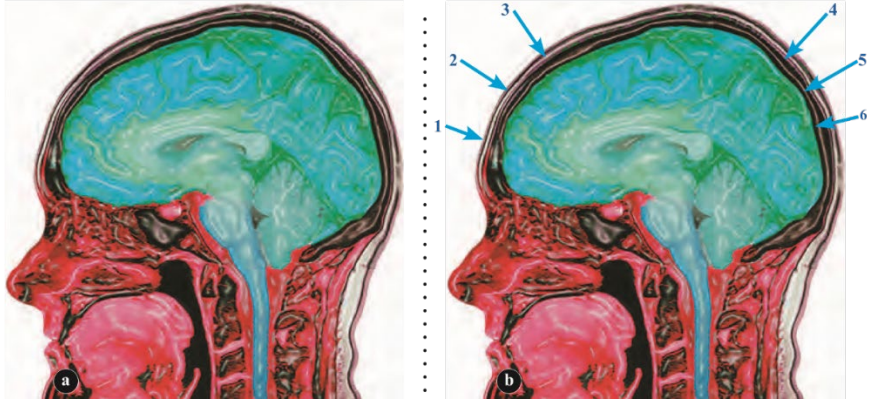


Fig. 1 Tomogram of human head in coronary projection

a. «Enlarged tomogram of the head» work of art. Authors: Mark Lithgow, Chloe Hatton;
b. Subdural spaces, skull and soft tissues of skull covers.

1 - Skin; **2** - Hypodermis; **3** - Aponeurosis; **4** - Skull; **5** - Dura mater; **6** - Subdural space.

We have also used drawings made by our prominent compatriot M.I. Pirogov from the book "An Illustrated Topographic Anatomy of Saw Cuts Made in Three Dimensions across the Frozen Human Body", published in the printing house of Jacob Gray in 1859 (pic. 2).

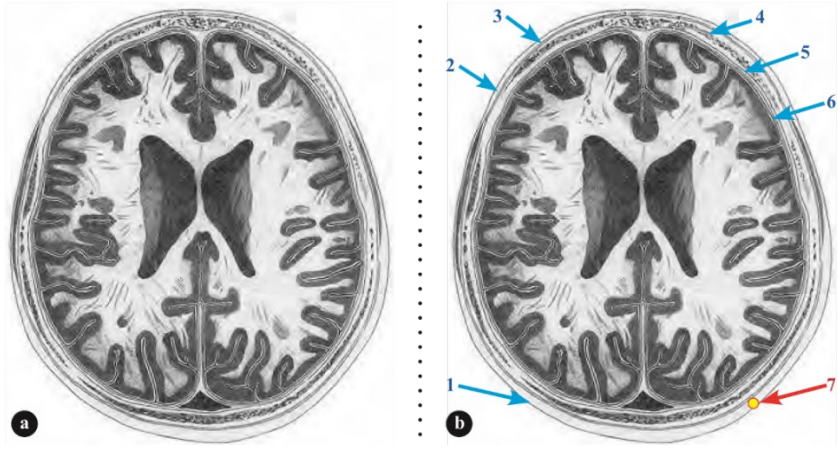


Fig. 2 Drawings from the book of Nikolai Ivanovich Pirogov. "An Illustrated Topographic Anatomy of Saw Cuts Made in Three Dimensions across the Frozen Human Body"

a. Saw cut of human skull in axial projection;
b. Subdural spaces, skull and soft tissues of skull covers.

1 - Skin; **2** - Hypodermis; **3** - Aponeurosis; **4** - Skull; **5** - Dura mater; **6** - Subdural space; **7** - Wounding projectile.

For an easy understanding of the scheme and CT images are provided mainly in axial projection. Respectfully, we tried to present the relevant material in detail and simply.

In this tutorial certain types of gunshot craniocerebral wounds are described according to the depth of tissue damage in such a classification:

- wounds of the soft tissues of the skull's arch;
- non-penetrating wounds;
- penetrating wounds of the skull and the brain.

We provide examples of various types of gunshot wounds of skull and cerebrum, as well as methodological guidelines and rules of work with the classification in the process of formulation of the expanded diagnosis in the medical institutions of 2 and 3 (4) levels.

The authors express special gratitude to the command of the Military Medical Clinical Center of the North Region, the leading neurosurgeon and the leading radiologist of the North region, heads of the mobile hospitals and their teams, as well as all managers and staff of neurosurgical teams of military hospitals for a great deal of work on treatment of wounded and the presented scientific material. A special acknowledgement from the authors to the management and staff of the I. I. Mechnikov Dnipro Regional Clinical Hospital (medical institution of the 3rd level of medical aid) for a huge collaboration on specialized neurosurgical assistance to the wounded and presented scientific CT material of three observations of gunshot penetrating craniocerebral wounds.

CHAPTER 1

General points of classification of gunshot wounds of skull and cerebrum Terminology

In most publications, **the classification of gunshot wounds of skull and cerebrum** is presented in the following way:

1. By the nature of the wound:
   - soft tissue wounds;
   - non-penetrating wounds;
   - penetrating wounds of skull and cerebrum.
2. By the form of the wounding projectile: ball, fragmentary.
3. According to the type of the wound channel:
   - blind: simple, radial, segmental, diametric;
   - cross-cutting: segmental, diametric;
   - tangential;
   - ricocheting.
4. By localization:
   - skull arches wounds: frontal, parietal, temporal, occipital area, a combination of areas.
   - parabasal: frontal (frontal orbital area, damage of paranasal sinuses, injuries of the eyeball), middle (temporomandibular area), posterior (rear cranial fossa, craniospinal).
5. By the side of the wound: right, left.
6. By quantity: single, multiple, combined wounds.
7. According to the types of fractures of the skull: incomplete, linear, pressed, fragmented, hollow, fragile.

The basis of the classification of gunshot wounds of the skull and cerebrum is primarily the allocation of the groups of wounded by nature of the wounds, precisely by the depth of tissue damage (wounds of soft tissues of skulls' arches, non-penetrating wounds, penetrating wounds of skull and cerebrum). Each of the above groups of gunshot craniocerebral wounds is characterized by certain peculiarities and differences in mechanisms, pathogenesis, anatomical lesions, clinical manifestations, and accordingly the methods of treatment. In this regard, it is expedient to consider the classification of each group separately, taking into account that the wounds are inflicted by balls or fragments of explosive shells and are divided according to the type of wounding projectiles into two groups: ball and fragmentary.

Some terms related to the classification of gunshot wounds of skull and cerembum

Gunshot wound of skull and cerebrum (gunshot wound of skull and brain) is a collection of pathological processes of the organism of the wounded wound conditioned to the damages of the soft tissues of the skulls' arches, skull, cerebrum caused by the direct impact of the damaging projectile (fragment, ball) or the effect on the tissue of secondary wounding elements (bone fragments, shards from helmet, etc.).

A wounding projectile is balls and / or fragments of explosives (mines, fougasses, etc.).

A wound channel is a collection of destroyed (smashed) soft tissues of the skulls' arches, skull bones, brain substance by wounding projectiles at the time of its' contact and advancement in the tissues.

Damage of the tissue is anatomical tissue changes caused by direct impact of the wounding projectile (fragments or balls) or by the impact of the secondary wounding elements (bone fragments, shardss from helmets, etc.).

Damage to the brain (as well as smashing, bulbing of the brain - the term for classification ICD 10S 07.8) is an anatomical change of substance of the brain and its elements caused by the direct impact of the wounding projectile (fragments, balls) or by the impact of secondary wounding elements (bone chips, shards from helmet, etc.).

Single (isolated) **wounds** of the skull and cerebrum are cause by one wounding projectile.

Multiple wounds of skull and cerebrum are caused by two or more wounding projectiles of one anatomical area of skull and cerebrum.

Multiple head wounds are wounds in which wounds of skull and cerebrum happen at the same time and are connected with injured eyesight, (or) hearing or maxillofacial area.

Connected wounds of skull and cerebrum are wounds in which there is a simultaneous gunshot wound of several anatomical areas (cerebrum and skull, combined with wounds of other anatomical areas: limbs, abdominal cavity, chest, etc.).

In modern military conflicts, the frequency of isolated wounds is 65%, multiple - 13%, connected - 22%.

Combined wounds of skull and cerebrum are wounds, trauma and damages resulting from simultaneous exposure of humans to two or more wounding factors and from the aggressive external effects of mechanical

and gunshot agents (for example, explosive fractured wounds of skull and cerebrum caused by mine and burns of soft tissues of skull's skin).

Combined wounds occur due to application of mechanical, thermal and / or chemical factors, which complicates the course of the disease and has peculiarities in providing assistance.

Some terms related to the organization of medical care for the victims of combat neurosurgery trauma are given below (in accordance with the "Guidelines for Military Field Surgery", Kyiv, 2014).

The system of medical and evacuation support is a combination of related principles of organization of medical care, treatment, evacuation

and rehabilitation of wounded and sick, aimed at the realization of tasks of medical service, which corresponds to the modern historical period, the level of development of military science, military medicine and the state system of health care in general.

Stage (echelon) **of medical evacuation** is a medical service

(first aid, field hospitals and medical institutions), which are deployed on the evacuation routes for receiving, sorting of the wounded and patients, providing them a certain level (type) of medical assistance that depends on combat and medical conditions and preparation for further evacuation by appointment.

The level of medical care is a complete complex of medical and preventive care measures that is carried out by troops and medical personnel on the battlefield, in the centre of mass casualties and at the stages of medical evacuation. The levels of health care are divided into:

0 - Basic level of medical care: first medical care and pre-care aid.

1 - First level of medical care: first medical aid.

2 - Second level of medical care: qualified medical aid.

3 - Third level of medical care: specialized medical care.

4 - The fourth level of medical care: specialized treatment.

5 - The fifth level of medical care: rehabilitation.

Neurosurgical aid is the highest form of medical care (specialized), which is exhaustive and performed by the relevant specialists neurosurgeons who are properly trained and equipped with the necessary medical diagnostic equipment in specially appointed institutions of the territorial bases.

CHAPTER 2 Gunshot wounds of soft tissues of the skull's arches

The gunshot wounds of the skull's arches soft tissues include wounds of the soft tissues of skull cover, in which the integrity of the skin, aponeurosis, muscles, and periosteum is broken by the wounding projectile - a bullet or a shell fragment. In case of such damage, immediate bacterial contamination tof the soft tissues of the skull's arches takes place.

The degree of anatomical damage to the soft tissue covers the skull and the anal-functional disorders of the brain from the kinetic energy of the early projectile, which is transmitted to the soft tissues and directly to the skull bones, transforming the skulls and intracranial traumatic lesions into soft lesions of soft animals, similar to the pathomorphological internal changes that occur in the craniocereal mechanical blunt trauma.

THE CLASSIFICATION OF THE GUNSHOT WOUNDS OF THE SKULL'S ARCHES SOFT TISSUES

The gunshot wounds of the skull's arches soft tissues are classified according to:
1. The type of the wounding projectile: bullet or fragmentary;
2. Localization: frontal, temporal, parietal, occipital, parietal-temporal et al.;
3. The nature of the wounded canal: blind, tangent, transverse, ricocheting;
4. The side of the wound channel and the wounding projectile: left, right;
5. Accompanying intracranial traumatic injuries: concussion, cerebral palsy, subdural hematomas, subarachnoid hemorrhages;
6. The number of injuries: single or plural;
7. Combination of injuries: those that are combined or not combined with wounds and injuries of other organs and systems (Table 2).

The analysis of various aspects of classification, as well as the process of formulating a diagnosis, begins with an assessment of points 6 and 7 to determine whether a gunshot wound is single or plural, combined or isolated. Afterwards, the data is analyzed according to the points 1-5 respectively.

Classification of firearms of soft tissues of the skull's arches
1. View of the wounded projectile: bullets or fragments
2. Localization: frontal, temporal, parietal, occipital, tympanoscopic, and the like.
3. The nature of the wound canal: blind (A), tangential (B), cross-cutting (C), rebounding (D)
4. The side of the wound channel and wound projectile: left or right
5. Accompanying intracranial traumatic injuries: concussion, cerebral palsy, subdural hematomas, subarachnoidal hemorrhages
6. Number of damages: single or multiple
7. Combination of injuries: combining or not combining with injuries and injuries of other organs and systems

BLIND GUNSHOT WOUNDS OF THE SKULL'S ARCHES SOFT TISSUES (A)

Most of the gunshot wounds of the skull's arches soft tissues happen due to wounding projectiles that have a small kinetic energy, which include fragile wounds (Fig. 3). This is so owing to the fact that the bullet has a much greater energy than a fragment, and it can damage the soft tissues of the cranial vault in the form of an exclusively tangent wound and only a bullet at a far distance from the exit point, which has already lost its energy and slaughter potential, on flying out, may just penetrate the soft skulls of the skull (unfinished blind wound of soft tissues). Theoretical grounds of the fact that ball wounds of the skull’s vault soft tissues can only be tangent and can’t be blind, transverse or ricocheting, are confirmed by observation in practice.

Fig. 3 Fragments removed during surgical intervention. The photo is real size.

Blind Gunshot Fragmentary Wounds of the Skull's Arches Soft Tissues (A) are classified into:

A.1. Single blind fragmentary gunshot wounds of the skull's arches soft tissues:

A.1.1. Single blind fragmentary gunshot wound of the skull's arches soft tissues;

A.1.2. Single blind fragmentary gunshot wound of the skull's arches soft tissues accompanied by a concussion of the brain;

A.1.3. Single blind fragmentary gunshot wound of the skull's arches soft tissues accompanied by a focal brain contusion.

A.2. Multiple blind fragmentary gunshot wounds of the skull's arches soft tissues:

A.2.1. Multiple blind fragmentary gunshot wound of the skull's arches soft tissues;

A.2.2. Multiple blind fragmentary gunshot wound of the skull's arches soft tissues, concussion of the brain;

A.2.3. Multiple blind fragmentary gunshot wound of the skull's arches soft tissues, concussion of the brain, accompanied by a focal brain contusion.

A.1. Single blind fragmentary gunshot wounds of the skull's arches soft tissues

When the kinetic energy of the wounding projectile is not big - the damage caused by it, as a rule, is limited to soft tissues of the skull's vault. In case of a sufficiently large kinetic energy of the wounding projectile, which damages the soft tissues of the skull's arch, but insufficient to break the skull, and in case of a tight mechanical contact of the wounding projectile and the skull, the transfer of the energy of the projectile to the bones of the skull and the brain by means of sharp mechanical shock is carried out. Depending on the magnitude of the transmitted energy there may also be a concussion, contusion, or compression of the brain by intracranial hematoma. In addition to wounds of soft tissues, damage of the periosteum may occur in the area of the collision of the fragment with the skull.

A.1.1. Single blind fragmentary gunshot wound of the skull's arches soft tissues

Single blind fragmentary gunshot wound of the skull's arches soft tissues occurs in cases when one wounding projectile (fragment) has small size and a certain but small and insufficient kinetic energy to damage the skull. The trajectory of its movement is at a direct or oblique angle to the spherical surface of the head (that is according the tangent that passes at the point of collision of the wounding projectile and the spherical surface of the skull), as a result, only the skin, aponeurosis and muscles are damaged.

Clinical observation 1

In case of a small kinetic energy of the fragment the damage is limited to soft tissues. A short wound canal, disposed at a straight or obtuse angle in relation to the spherical surface of the skull, is limited to damaged soft tissues, ends blindly, and as a rule, at the bottom of it a wounding projectile is located (Fig. 4).

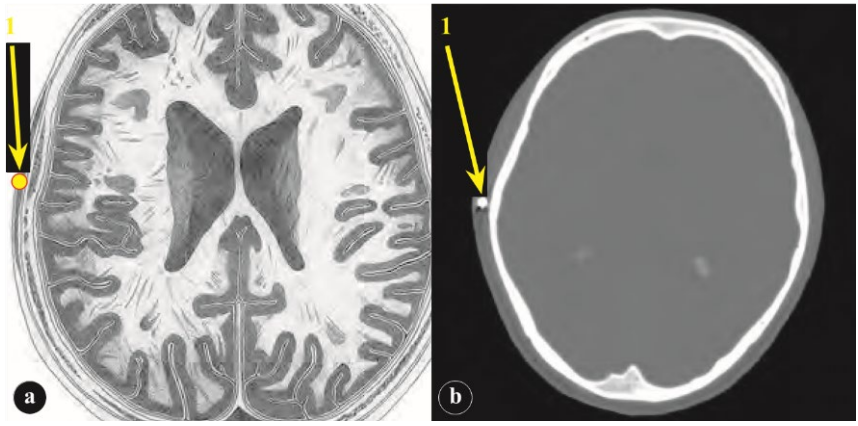


Fig. 4 Single-blind fragmentary gunshot wound of the skull's arches soft tissues.

a. Schematic image of a wound;
b. Computed tomography of the wounded.

1 - Wounding projectile (fragment).

Example of the diagnosis formulation (A.1.1): *a single blind fragmentary gunshot wound of the skull's arches soft tissues in the right parietal lobe.*

A.1.2. Single blind fragmentary gunshot wound of the skull's arches soft tissues accompanied by a concussion of the brain

In case of a single blind fragmentary gunshot wound of the skull's arches soft tissues accompanied by a concussion of the brain (Fig. 4) the following diagnosis may be formulated (A.1.2.): blind fragmentary gunshot wound of the skull's arches soft tissues in the right temporal lobe, concussion of the brain.

A.1.3. Single blind fragmentary gunshot wound of the skull's arches soft tissues accompanied by a focal brain contusion.

Clinical observation 2

The center of brain injury is usually located directly under the skull at the point of collision with a wounding projectile (fragment). In fig. 5 computer tomograms and the scheme of a blind fragmentary gunshot wound of the skull's arches soft tissues in the posterior sections of the left fronto-temporal lobe, the focal contusion of the posterior sections of the left frontal lobe of the brain are presented.

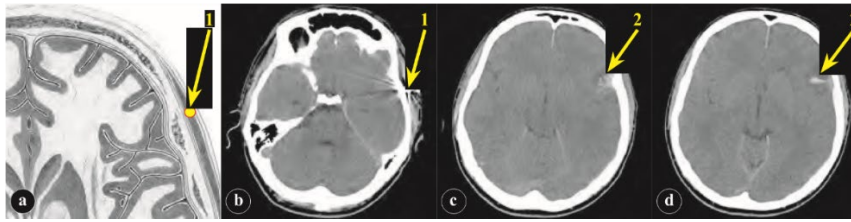


Fig. 5 A blind fragmentary gunshot wound of the skull's arches soft tissues in the left temporal lobe, the focal contusion of the brain's left frontal lobe:

a. Schematic image of the wound;
b-d. Computer tomograms of the wounded.

1 - Wounding projectile (fragment); **2** - Focal contusion of the brain.

Example of the diagnosis formulation (A.1.3): *blind fragmentary gunshot wound of the skull's arches soft tissues in the posterior sections of the left frontotemporal lobe, focal contusion of the posterior sections of the left frontal lobe of the brain.*

A.2. Multiple blind fragmentary gunshot wounds of the skull's arches soft tissues

Multiple blind fragmentary gunshot wounds of the skull's arches soft tissues occur in cases when two or more wounding projectiles (fragments) have small size and insufficient kinetic energy to damage the skull, by analogy to single blind wounds of soft tissues. Owing to it, the damage is related only to the skin, aponeurosis and muscles.

Clinical observation 3

Short wound canals, located at a straight or obtuse angle to the tangent, that pass at the point of collision of the projectile with a spherical surface of the skull. Damage is limited to soft tissues, ends blindly, and usually wounding projectiles are located at the bottom of the wound. By analogy to single fragmentary blind wounds of soft tissues of the skull's arches, multiple wounds of soft tissues of the skull's arches may cause concussion and contusion (Fig. 6).

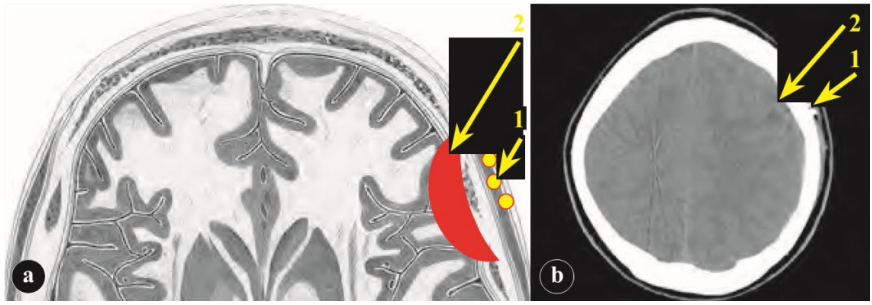


Fig. 6 Multiple blind fragmentary gunshot wounds of the skull's arches soft tissues in the left frontal area, accompanied by focal contusion of the brain:

a. Schematic image of the wound;
b. Computed tomography of the wounded 4 weeks after the injury.

1 - Wounding projectiles; **2** - Focal brain contusion.

Example of the diagnosis formulation (A.1.3): *multiple blind fragmentary gunshot wound of the skull's arches soft tissues in the left frontal area, focal contusion of the brain in the posterior sections of the left frontal lobe.*

THE TANGENT GUNSHOT WOUNDS OF THE SKULL'S ARCHES SOFT TISSUES (B)

The term "tangent" is a mathematical term denoting a straight line which has a common point with the curve but does not cross it. In tangent injuries, the "common point" refers to the point of collision (contact) of the wounding projectile with a certain area of the head's soft tissue. In case of tangent wounds, the bullet or fragment shell instantly damages the soft tissues and leaves the wound area (Fig. 7-a).

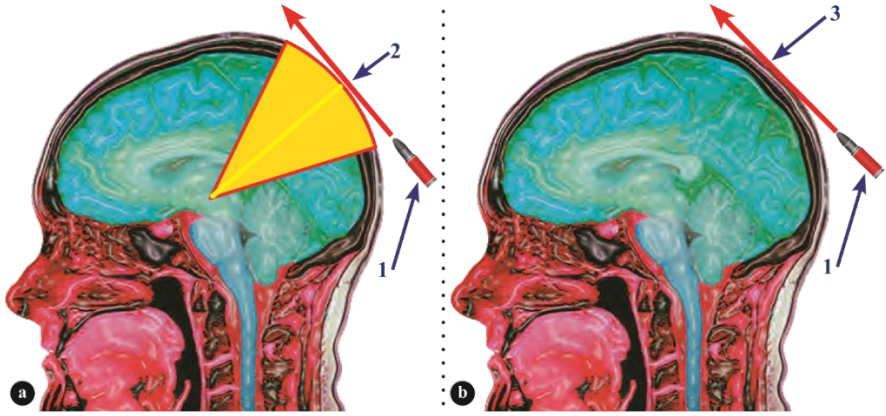


Fig. 7 Schematic images of the tangent gunshot wounds of the skull's arches soft tissues

1 - Wounding projectile; **2** - Point of contact of the wounding projectile with a certain area of soft tissue of the head; **3** - Trajectory of the movement of the wounding projectile

The tangent gunshot wounds of the skull's arches soft tissues **(B)** are classified into:

B.1. The tangent gunshot wound of the skull's arches soft tissues;

B.2. The tangent gunshot wound of the skull's arches soft tissues, accompanied by concussion of the brain;

B.3. The tangent gunshot wound of the skull's arches soft tissues, accompanied by a focal brain contusion;

B.4. The tangent gunshot wound of the skull's arches soft tissues, accompanied by a compression of the brain by subdural haematoma on the background of a focal brain contusion.

In case of a small kinetic energy of the wounding projectile, damage is limited to soft tissues. In case of a great kinetic energy of the projectile and a tight mechanical contact with the skull, the energy transfer to the skull and the brain is carried out by the type of mechanical shock. This, depending on the amount of energy transferred, leads to concussion, contusion, or compression of the brain by intracranial haematoma. Apart from wounding the skull's arches soft tissues, periocranium may be damaged in the point of contact of the projectile and the skull.

B.1 The tangent gunshot wound of the skull's arches soft tissues;

If the damaging projectile has a small kinetic energy and does not collide with the skull, then the vector of this energy is directed along the course of the projectile movement, while only soft tissues are damaged (Fig. 7-b).

In this case there is a tangent gunshot wound of the skull's arches soft tissues.

An example of the formulation of the diagnosis (B.1): *a ball tangent gunshot wound of the skull's arches soft tissues in the posterior sections of the right parietal lobe.*

B.2. The tangent gunshot wound of the skull's arches soft tissues, accompanied by concussion of the brain

In cases when the tangent gunshot is accompanied by a clinical picture of the concussion of the brain, the formulation of the diagnosis will be as follows (B.2): *a ball tangent gunshot wound of the skull's arches soft*

tissues in the posterior sections of the right parietal lobe, concussion of the brain.

B.3. The tangent gunshot wound of the skull's arches soft tissues, accompanied by a focal brain contusion

Clinical observation 4

Fig. 8 shows the mechanism of the tangent fragmentary fracture wound of the skull's arches soft tissues in a parasaggital plane in the parietal lobes, due to fractional charge shot from a close distance. The wounding shell in the form of a large number of fractions of different sizes and weights flies with a single compact mass and, as a rule, leads to significant damage to the tissues.

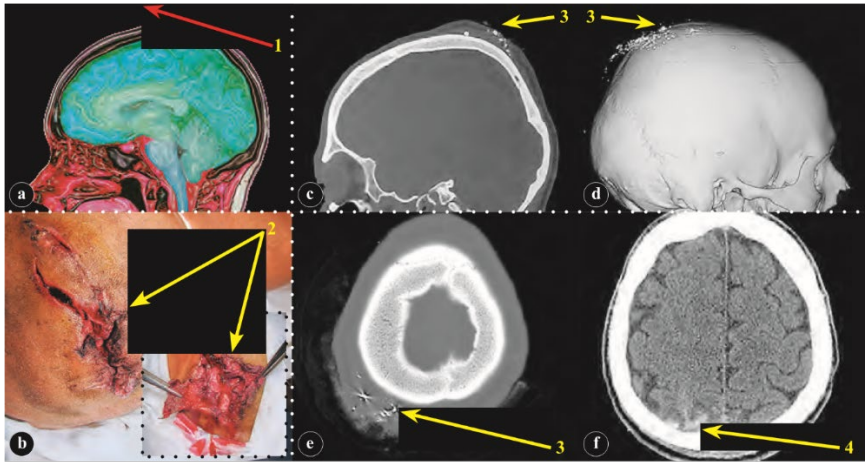


Fig. 8 The tangent fragmentary fracture wound of the skull's arches soft tissues in a parasaggital plane in the parietal lobes, accompanied by focal brain contusion:

a. Scheme of the wound;
b. Photos of the soft tissues wound;
c-f. Computed tomography scans of the wounded 15 hours after the wounding.

1 - Trajectory of the wounding projectiles motion; **2** - Wound of the soft tissues; **3** - Fragments in the wound of soft tissues; **4** - focal brain contusion.

Example of diagnosis formulation (B.3): *The tangent fragmentary fracture wound of the skull's arches soft tissues in the parietal lobes, focal brain contusion on the left side of the parietal lobe, subarachnoid hemorrhage.*

B.4. The tangent gunshot wound of the skull's arches soft tissues, accompanied by a compression of the brain by subdural haematoma on the background of a focal brain contusion of severe degree

Clinical observation 5

An example of a tangent gunshot wound of the shull's arches soft tissues, accompanied by a focal brain contusion of severe degree, subarachnoid haemorrhage, intracerebral haemorrhage, and subdural haematoma is shown in Fig. 9

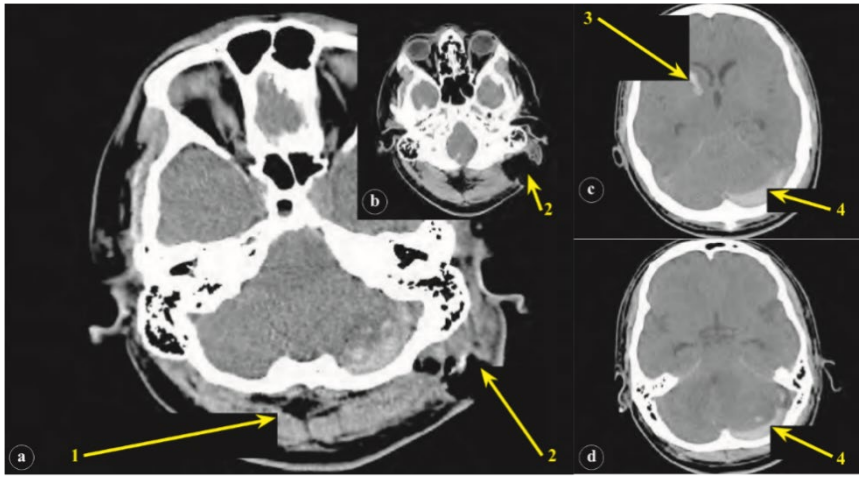


Fig. 9 A ball tangent gunshot wound of the skull's arches on the left side of the occipital lobe, accompanied by a focal brain contusion of severe degree and subdural haematoma.

a-d. Computer tomograms of the wounded.

1 - Subgaleal hematoma; **2** - Big gunshot wound of the soft tissues;
3 - Intracerebral haemorrhage; **4** - Subdural hematoma.

Formulation of Diagnosis (B.4): *A ball tangent gunshot wound of the soft tissue on the left side of the occipital lobe, focal brain contusion of severe degree, subarachnoid hemorrhage and subdural haematoma in the left occipital lobe.*

Clinical observation 6

Fig. 10 shows the case of a ball tangent gunshot wound of the soft tissues of the skull's arches on the left side of the frontal-parietal lobe. The appearance of the wound in 6 days after the injury, provision of primary care and an initial surgical debridement are shown in Fig. 10-a; data of CT-research on arrival at National Military Medical Clinical Center "Main Military Clinical Hospital" - Fig. 10-b; photo during a repeated surgical intervention -Fig. 10-c and 10-d.

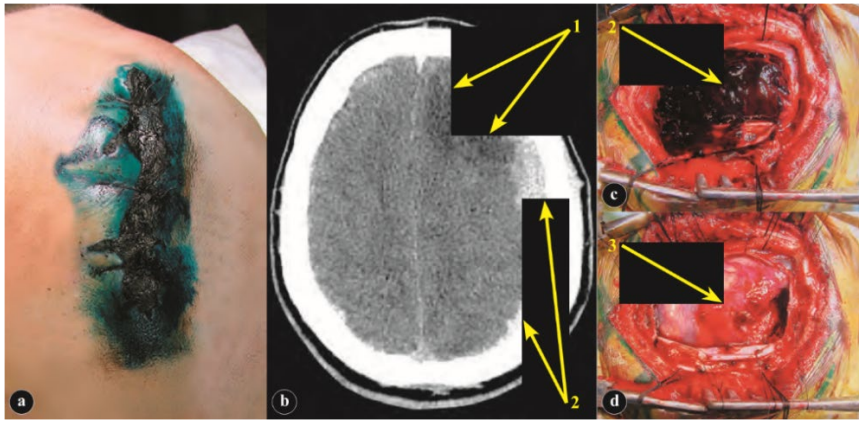


Fig. 10 A ball tangent gunshot wound of the soft tissues of the skull's arches in the left frontal-parietal lobe, accompanied by a compression of the brain by a subacute subdural hematoma in the left frontal-parietal-temporal lobe and a focal brain injury of the frontal lobe.

- The soft tissue wound 6 days after an initial surgical debridement;
- Computed tomography of the wounded;
- -D. Intraoperative photos during repeated surgical intervention. 1 - The hearth of the focal brain injury of the frontal lobe; 2 - Subdural hematoma; 3 - The wound after removal of subdural hematoma.

An example of the formulation of the diagnosis (B.5): *A ball tangent gunshot wound of the soft tissues of the skull's arches in the left frontal-parietal lobe, a compression of the brain by a subacute subdural hematoma in the left frontal-parietal-temporal lobe, accompanied by and a severe focal brain injury of the left frontal lobe, subarachnoid hemorrhage.*

TRANSVERSE GUNSHOT WOUNDS OF THE SKULL'S ARCHES SOFT TISSUE(C)

Transverse gunshot wounds of the skull's arches soft tissues are caused by a small size wounding object in the form of small fragments in diameter no more than 2 - 2,5 mm and are extremely rare. In this case, the soft tissues of the skull's arches are damaged in the frontal and parietal tubers (fig. 11), as a rule, without traumatic brain damage.

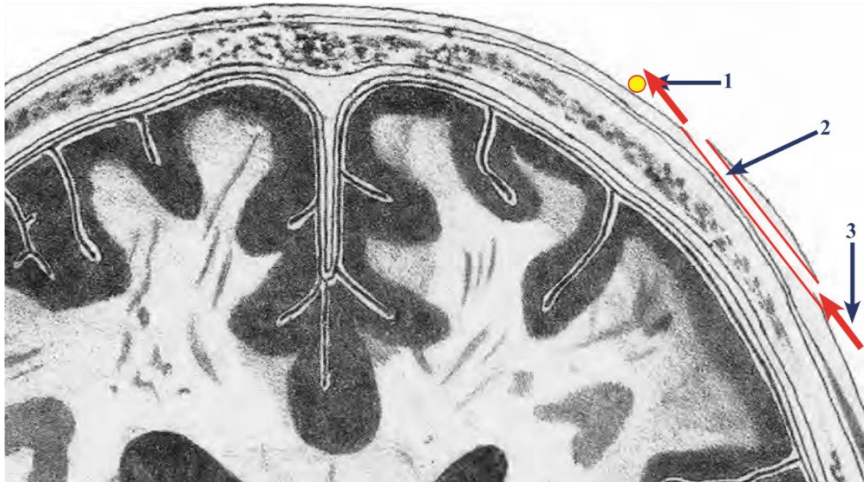


Fig. 11 Scheme of the transverse gunshot wound of the skull's arches soft tissues in the right frontal tuber of the lobe.

1 - Wounding projectile (fragment); **2** - Wound channel; **3** - Trajectory of the wounding projectile movement.

An example of the diagnosis formulation: *a transverse fragmentary gunshot wound of the skull's arches soft tissues in the right frontal tuber.*

CHAPTER 3 Gunshot non-penetrating wounds of skull and cerebrum

Gunshot non-penetrating wounds of skull and cerebrum are wounds in which soft tissues of the arches of skull and skull bones are damaged, but the integrity of the dura mater is preserved. Non-penetrating wounds are accompanied by contusion of the brain (sometimes diffuse contusions), as well as by compression of the brain by intracranial hematomas and compressed fractures.

Maintaining the integrity of dura mater is a factor that protects brain and smooth areas from the spread of infection from the wound. *In this case there is a direct bacterial contamination of soft tissues of the arches of the skull, skull bones and epidural space in the area of the wound.*

The degree of anatomical destruction of soft tissues of the skull's covers, skull bones and anatomical and functional brain disorders depends on the part of the kinetic energy of the wounding projectile, which is transmitted to soft tissues and directly to the skull bones, transforming into the gunshot damages of the soft tissues of the arches and fractures of skull bones. The energy of the lateral impact of the fragment is transformed into intracranial traumatic wounds, similar to the pathomorphological intracranial changes occurring in the craniocerebral mechanical blunt trauma.

CLASSIFICATION OF GUNSHOT NON-PENETRATING WOUNDS OF SKULL AND BRAIN

Gunshot non-penetrating wounds of skull and brain are classified by:
1. Type of wounding projectile: *ball or fragmentary;*
2. Localization: *frontal, temporal, parietal, occipital, parietal temporal, etc.;*
3.a. The nature of the wound channel: *blind, tangent;*
3.b. The side of the location of wound channel and the wounding projectile: *left, right;*
4. Type of skull fracture: *incomplete, linear, pressed, hollow;*

5. Accompanying intracranial traumatic injuries: *focal brain injury, subarachnoidal hemorrhage, subdural hematomas, epidural hematomas, intracerebral hematomas;*
6. The number of injuries: *single or multiple;*
7. Combination of injuries: *those that are accompanied by or not accomanied by injuries and trauma of other organs and systems* (table 3).

Table 3.

CLASSIFICATION OF GUNSHOT NON-PENETRATING WOUNDS OF SKULL AND BRAIN
Type of wounding projectile: ball or fragmentary
2. Localization: frontal, temporal, parietal, occipital, parietal temporal, etc.
3.a. The nature (type) of the wound channel: blind **(A)**, tangent **(B)**;
3.b. The side of location of wound channel and the wounding projectile: left, right;
4. Type of skull fracture: incomplete, linear, pressed, hollow;
5. Accompanying intracranial traumatic injuries: focal brain injury, subarachnoidal hemorrhage, subdural hematomas, epidural hematomas, intracerebral hematomas;
6. The number of injuries: single or multiple;
7. Combination of injuries: those that are accompanied by or not accomanied by injuries and trauma of other organs and systems

Consideration of various aspects of classification, as well as the process of formulating a diagnosis, **begins with an assessment of points 6 and 7** to get an answer to the question: is a gunshot wound single or multiple, combined or isolated; further on, the data corresponding to the points 1 to 5 is analyzed.

It should be noted that all gunshot non-penetrating craniocerebral wounds regardless of the type of wound channel can be divided into two groups according to the nature of brain damage:

1. gunshot non-penetrating craniocerebral wounds, which are accompanied by brain injuries, subarachnoid hemorrhage and various fractures of the skull;

2. gunshot non-penetrating craniocerebral injuries, which are accompanied by compression of the brain, compressed fracture or intracranial hematomas (subdural, epidural, intracerebral).

TYPES OF FRACTURES OF THE SKULL IN GUNSHOT NON-PENETRATING CRANIOCEREBRAL WOUNDS AND THEIR CHARACTERISTICS

In gushot non-penetrating craniocerebral wounds the following types of fractures of the skull are distinguished:

- incomplete;
- linear;
- pressed;
- hollow

An incomplete fracture is characterized by damage only to the outer plate of the skull and the spongy substance of the bone, with the inner plate retained undamaged.

Linear fracture is characterized by linear damage to the bone in its entire thickness - the outer plate, the spongy substance and the inner plate of the skull for a certain length (pic. 12).

Pressed fracture is a bone damage in its entire thickness, with the formation of several bone fragments that have lost contact with each other and in the form of fragments are displaced into the cranial cavity (pic. 13).

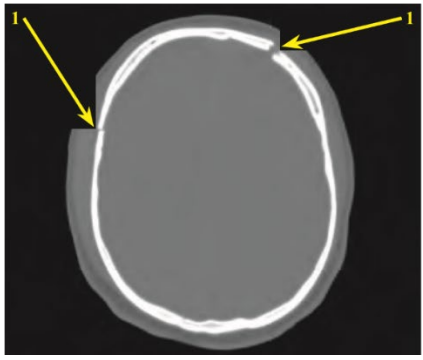


Fig. 12
Linear fracture of skull.
Computed tomography of the wounded.
1 Linear fracture.

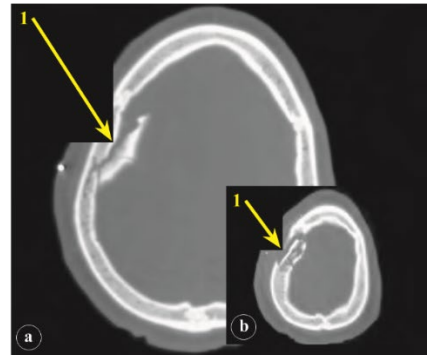


Fig. 13
Pressed fracture of skull.
Computed tomography of the wounded.
1 Pressed fracture.

A hollow fracture with the presence of a wounding projectile at the end of the bone wound channel, without damage to dura mater, is characterized by the formation of a rounded form with relatively straight edges of a wound channel in the form of a skull defect corresponding to the size of the wounding projectile that is located at the end of bone wound channel. Fig. 14 shows CT and 3D CT images of a rare form of hollow fracture with the wounding projectile at the end of the bone wound channel, without damage to dura mater.

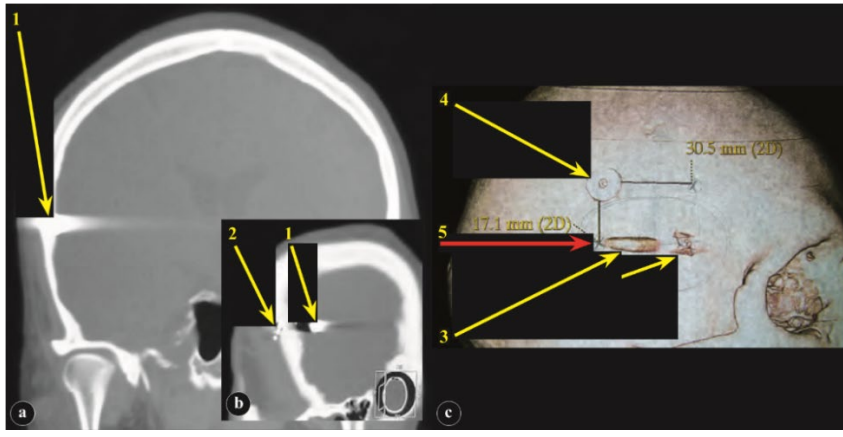


Fig. 14 Hollow fracture of skull with the wounding projectile at the end of the bone wound channel, without damage to dura mater.

a-b. Computer tomographies of the wounded;
c. 3D projection of the skull represented according to the data from the tomography of the wounded.

1 – Wounding projectile; **2**- Hollow fracture; **3**- Hollow fracture in the form of the wound channel in 3D CT research; **4** - Pre-surgery mark; **5** - The trajectory of the fragment's movement.

The examples of gunshot non-penetrating craniocerebral wounds that are accompanied by contusions of the brain, subarachnoid haemorrhages, various gunshot fractures of the skull, and of brain pressure with a compressed fracture or intracranial hematoma (subdural, epidural, intracerebral) are provided below.

CLINICAL EXAMPLES OF GUNSHOT NON-PENETRATING WOUNDS OF SKULL AND CEREBRUM

Clinical observation 7

Fig. illustrates the case when the CT of the skull and cerebrum scan of the wounded made the impression of a penetrating fragmentary wound of skull and cerebrum. However, during a surgical intervention, a non-penetrating wound was diagnosed: the fragment did not damage the dura mater. On the photos of the polished bone flap during initial surgical d-bridement it is visible: the fragment pierced the bone of the skull just by half of its size and stuck in its thickness.

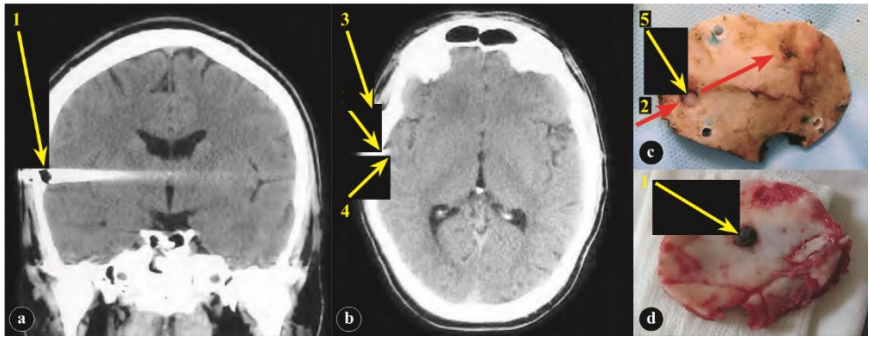


Fig. 15 Gunshot fragmentary non-penetrating blind craniocerebral wound in the right frontal temporal area, focal injury of the right frontal lobe of a mild degree, hollow gunshot fracture of frontal bone on the right and subarachnoid hemorrhage.

a-b. Computer tomographies of the wounded;
c-d. The polished bone flap during initial surgical d-bridement: outer (C) and inner (D) sides.

1 - Fragment in size of 6 mm in diameter in width of frontal bone;
2- Trajectory of the fragment; **3**- Hemorrhage in the soft tissue of the wound; **4**- Focal injury of the frontal lobe; **5**- Opening of the fragment in the frontal bone.

Example of the diagnosis formulation: *a gunshot non-penetrating, fragmentary blind craniocerebral wound in the right frontal-temporal region, a focal injury of the right frontal lobe, a hollow gunshot fracture of the frontal bone on the right, a subarachnoid hemorrhage (Fig. 15).*

Clinical observation 8

Fig. 16 shows CT studies of the wounded with a gunshot non-penetrating multiple fragmentary blind craniocerebral wound in the right parietal frontal lobe with compression of the cerebrum, pressed fracture of the frontal bone on the right, focal brain injury of the right frontal lobe of moderate severity, subarachnoid hemorrhage.

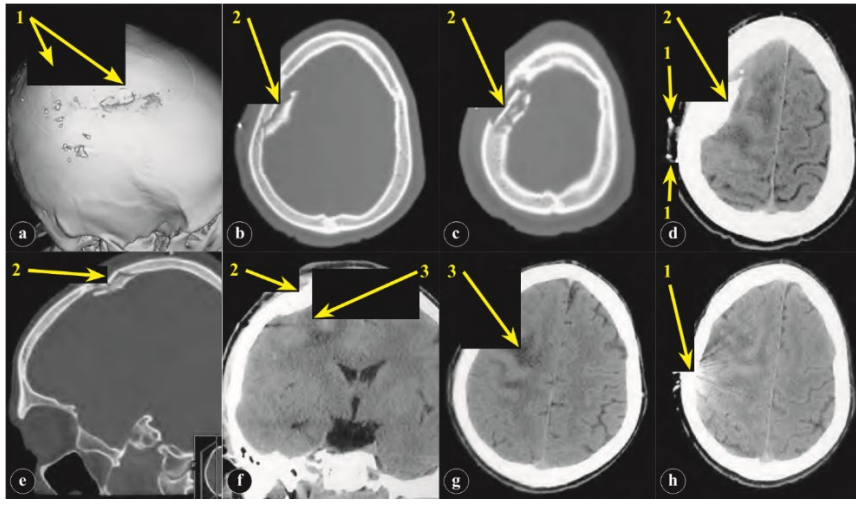


Fig. 16 A gunshot multiple fragmentary non-penetrating multiple fragmentary blind wound of skull and cerebrum in the right parietal frontal lobe, pressed fracture of the right frontal bone, focal brain injury of the right parietal lobe.

a-h. Computed tomography of the wounded.

1 – Wounding projectiles; **2** – Pressed fracture; **3** – Focal injury (in 5 days after the injury).

Example of the diagnosis formulation: *a gunshot non-penetrating multiple fragmentary blind craniocerebral wound in the right frontal parietal lobe, compression of the brain, pressed fracture of the frontal bone on the right, focal injury of the right frontal lobe of moderate severity, subarachnoid hemorrhage (Fig. 16).*

Clinical observation 9

Fig. 17 shows the case of a gunshot non-penetrating ball tangential craniocerebral wound in the posterior regions of the frontal area and in the parietal regions above the interparietal suture, the fracture of the posterior sections of the frontal bone (above the sagittal sinus) with an injury of the brain of moderate severity, subarachnoid hemorrhage.

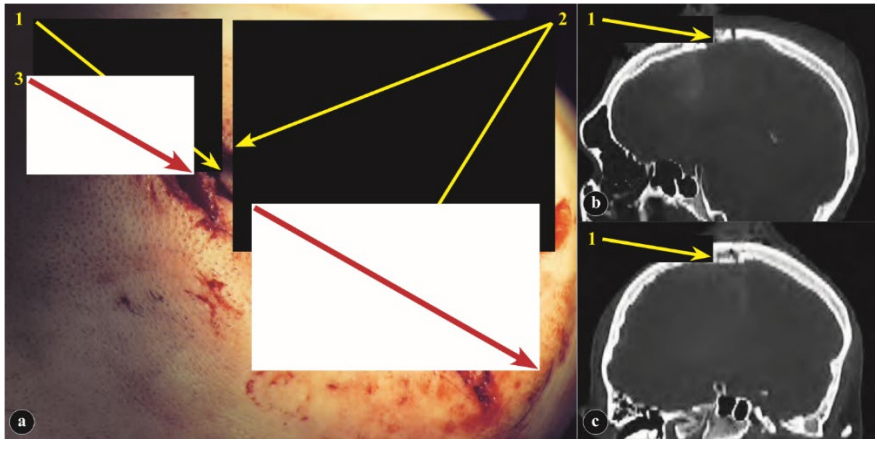


Fig. 17 A gunshot non-penetrating ball tangential craniocerebral wound in the posterior regions of the frontal area and in the parietal regions above the interparietal suture, the fracture of the posterior sections of the frontal bone (above the sagittal sinus), an injury of the brain of moderate severity, subarachnoid hemorrhage.

- Intraoperational photo: wound of the soft tissues;

b-c. Computed tomography of the wounded.

1 – Fracture of the posterior regions of the frontal lobe; **2** – A big deep injury of the skull's arches soft tissues; **3** – The trajectory of wounding projectile (ball).

An example of diagnosis formalution: *a gunshot non-penetrating ball tenagential craniocerebral wound in the posterior regions of frontal area and in the parietal regions over the interparietal suture, pressed fracture of the posterior sections of the frontal bone (over the sagittal sinus), injury of the brain of moderate severity, subarachnoid hemorrhage (Fig. 17).*

Clinical observation 10

The case of a gunshot non-penetrating fragmentary blind craniocerebral injury in the right temporal region with compression of the brain by an epidural hematoma in the right temporal region and a hollow fracture of the scales of the right temporal bone is shown in Fig. 18.

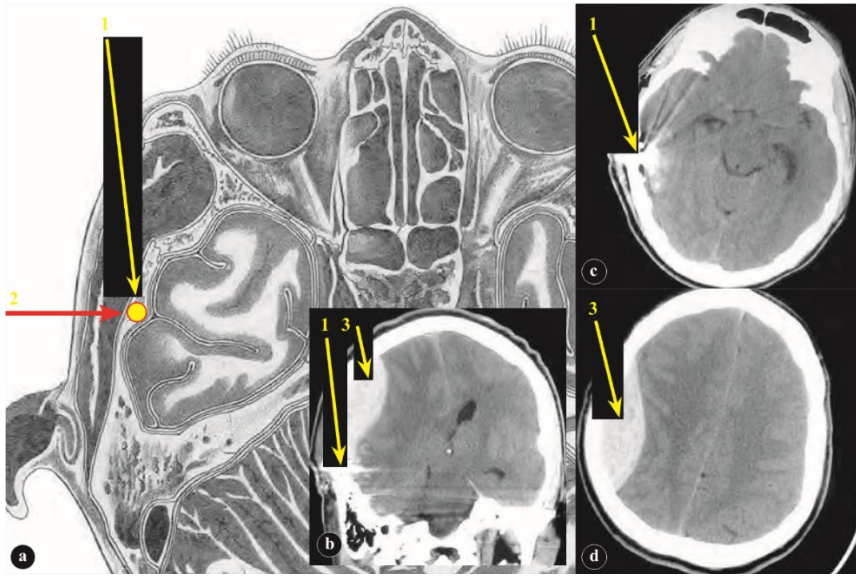


Fig. 18 Gunshot non-penetrating fragmentary blind craniocerebral wound in the right temporal region with compression of the brain by epidural hematoma in the right parietal temporal region and a hollow fracture of the scales of the right temporal bone.

- Schematic image of the injury;

b-d. Computer tomograms of the wounded

1 – Wounding projectile (fragment); **2** – Trajectory; **3** – Epidural hematoma.

The formation of the epidural hematoma in the right temporal region is due to the fragmented damage of the branches (III and IV level of the branching) of the right middle membrane artery (Fig. 19).

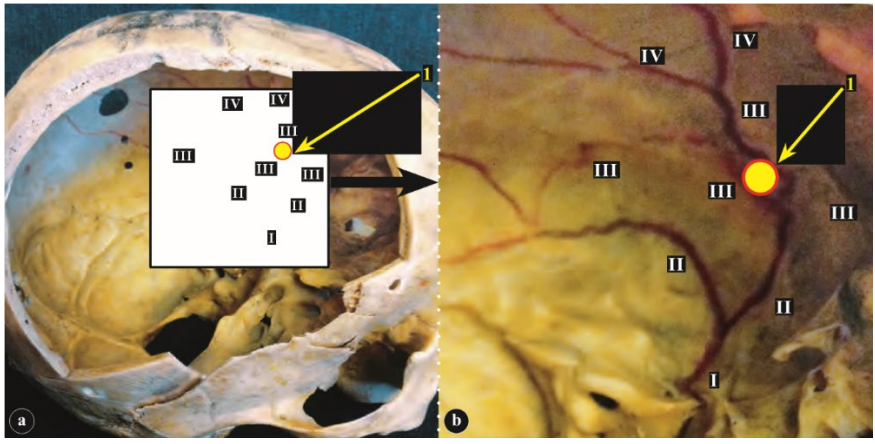


Fig. 19 A hypertencionally dislocated cerebral hemisphere syndrome – compression of the hemisphere of the lobe due to epidural hematoma that formed as a result of the damage of the branches of the third (III) level of division *a.meningea media* above the area, limited by the middle skull pit.

a-b. A photography of the skull inside with different zoom.

- Wounding projectile (fragment).

Example of diagnosis formulation: *a gunshot non-penetrating fragmentary blind craniocerebral wound in the right temporal region with compression of the brain by an epidural hematoma in the right temporal region that arose due to damage to a.meningea media and a hollow fracture of the scales of the right temporal bone.*

Clinical observation 11

A gunshot multiple fragmentary non-penetrating blind wound of the left temporal region, compressed fracture of the left temporal bone,

intracerebral hematoma in the area of the focal injury of the left temporal lobe is shown in Fig. 20.

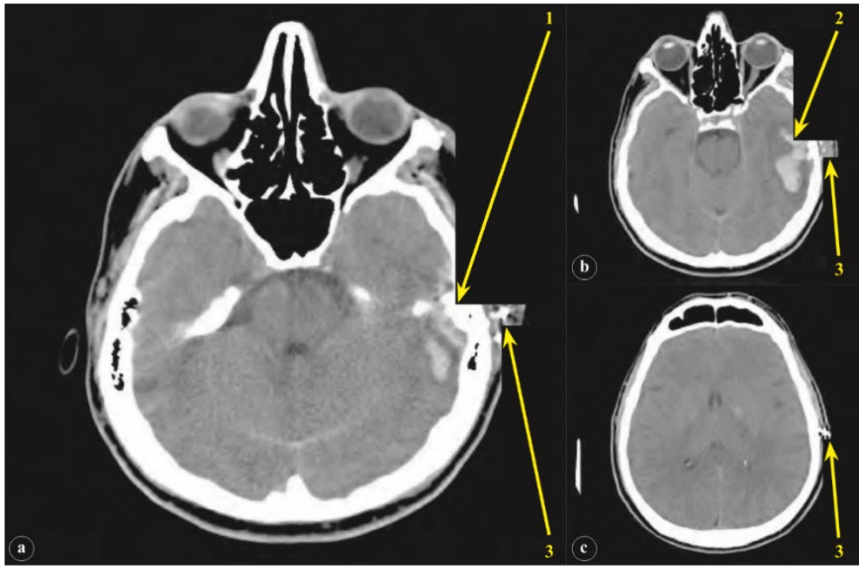


Fig. 20 A gunshot multiple fragmentary non-penetrating blind wound of the left temporal region with compressed fracture of the left temporal bone and intracerebral hematoma in the area of the focal injury of the left temporal lobe.

a-c. Computed tomography of the wounded.

1 – Compressed fracture; **2** – Focal injury; **3** – Wounding projectiles (fragments).

Example of diagnosis formulation: *a gunshot non-penetrating multiple fragmentary blind wound of the left temporal region, intracerebral hematoma in the area of the focal injury of the left temporal lobe, subarachnoid hemorrhage, pressed fracture of the left temporal bone.*

CHAPTER 4

Gunshot penetrating wounds of skull and cerebrum

Gunshot penetrating wounds of skull and cerebrum are wounds in which there are damages of the soft tissues of the skull's arches, gunshot bone fracture of the arch or the base of the skull, damage to the integrity of dura mater, damage to the brain and its structures. In this type of damage there is a direct bacterial contamination of the aforementioned tissues, including substances of the brain and cerebrospinal fluid. We propose a working classification of gunshot penetrating wounds of skull and cerebrum, which is based on three groups of wounds according to homogeneous features:

A. Wounds of skull's arches and cerebrum are craniocerebral wounds in which a wounding projectile penetrates the cranial cavity through its arches.

B. Parabrasal wounds, in which a wounding projectile enters the cavity of the skull in the region of its base.

C. Ricocheting wounds - wounds that have significant differences from the wounds of the first groups by the nature of secondary cerebrum wounding agents - bone fractures.

CLASSIFICATION OF GUNSHOT PENETRATING WOUNDS OF SKULL AND CEREBRUM

Gunshot penetrating wounds of skull and cerebrum are classified according to the following features:

1. Type of the wounding projectile: *ball or fragmentary;*

2. Localization of the wound of soft tissues of skull's arches or the base of the skull (entrance wound). In cases of penetrating wounds the localization of the exit wound is also indicated: frontal, temporal, parietal, occipital, parietal temporal, frontal parietal, etc.:

A. Wound of skull's arches and cerebrum: *frontal, parietal, temporal, occipital, parietal temporal, frontal parietal, etc.;*

B. Parabrasal wounds:

• **frontal:** *front orbital area, damage to paranasal sinuses, wounds of the eyeball;*

• **medium:** *temporomandibular region;*

• **back:** *rear cranial fossa, craniospinal;*

C. Ricocheting wounds: frontal; parietal; temporal; occipital; parietal temporal, frontal parietal, etc.;

3.a. Nature (type) of the wounding channel:

A. Wounds of skull's arches:

• **blind:** *simple, radial, segmental, diametric;*

• **perforating:** *segmental, diametric;*

• **tangible;**

• Parabrasal wounds:

• **blind:** *simple, radial, segmental, diametric;*

• Ricocheting wounds:

• **blind:** *simple, radial;*

• *the channels are formed by secondary wounding elements* - bone fractures;

3.b. Localization of the wounding channel in the lobes of the brain: *frontal, temporal, parietal, occipital hemisphere of the brain;*

3.c. Localization of the damaging projectile in the lobes of the brain and its depth from the entrance wound: *frontal, temporal, parietal, occipital, hemisphere of the brain;*

3.d. Localization and number of bone fractures in lobes of the brain and their depth from the entrance wound: *frontal, temporal, parietal, occipital, hemisphere of the brain;*

4. The side of the wounding channel and wounding projectile in the cerebral hemispheres: *left, right;*
5. Types and localization of fractures of the skull:
A. Damage of the skull's arches: *linear, hollow, fragmented, chipped;*
B. Parabasal wounds: *hollow, linear;*
C. Ricocheting wounds: *linear, fragmented, hollow, chipped;*
6. The number of damages: *single or multiple;*
7. Combination of wounds: *those that are combined or not combined with injuries and trauma of other organs and systems.*

We offer the classification of gunshot penetrating wounds of the skull and cerebrum in a form of a table (Table 4) which, in our opinion, will be convenient and easy to use.

<table>
<tr><th colspan="4">Classification of gunshot penetrating craniocerebral injuries</th></tr>
<tr><th>A. Injuries to the cranial vault and brain</th><th colspan="2">B. Parabasal injuries</th><th>C. Ricochet injuries</th></tr>
<tr><td colspan="4">1. Type of wounding projectile:
bullets or shrapnel</td></tr>
<tr><td colspan="4">Localization of a wound of the soft tissues of the skull vault or the base of the skull (entry wound). In case of the through wounds, the localization of the exit wound is also indicated.</td></tr>
<tr><td rowspan="3">Frontal
Parietal
Temporal
Occipital
Parieto-temporal
Frontoparietal
Etc.</td><td>Frontal</td><td>frontal-orbital area, paranasal sinus injuries, eyeball injury</td><td rowspan="3">Frontal
Parietal
Temporal
Occipital
Parieto-temporal
Frontoparietal
Etc.</td></tr>
<tr><td>Central</td><td></td></tr>
<tr><td>P</td><td></td></tr>
</table>

<table>
<tr><td colspan="3">a. Nature (type) of wound channel</td></tr>
<tr><td>Blind
simple, radial, segmental, segmental two-channel, diametrical, diametrical two-channel</td><td rowspan="2">Blind
simple, radial, segmental, diametrical</td><td rowspan="2">Blind
simple, radial</td></tr>
<tr><td>Penetrating
segmental, diametrical</td></tr>
<tr><td></td><td>c
h
a
n</td></tr>
<tr><td colspan="3">3.b. Localization of the wound channel in the lobes of the brain
frontal, temporal, parietal, occipital, and cerebral hemispheres</td></tr>
<tr><td colspan="3">e. Localization of the damaging projectile in the lobes of the brain and its depth from the entrance wound
frontal, temporal, parietal, occipital, and cerebral hemispheres</td></tr>
<tr><td colspan="3">3.d. Localization and quantity of bone fragments in the brain lobes and their depth from the entrance wound
frontal, temporal, parietal, occipital, and cerebral hemispheres</td></tr>
<tr><td colspan="3">4. L
Left or right hemisphere
h</td></tr>
<tr><td colspan="3">5. Type and localization of skull fractures</td></tr>
<tr><td></td><td>perforated, linear</td><td>linear, fragmented, perforated, shattered</td></tr>
<tr><td colspan="3">6. Number of injuries:
single or multiple</td></tr>
<tr><td colspan="3">7. Combination of injuries:
those that are connected or not connected with injuries and traumas of other organs and system</td></tr>
</table>

TYPE OF WOUNDING PROJECTILE

There are such types of gunshot penetrating craniocrebral wounds as ball and fragmentary.

There can be such fragments as metallic elements of explosive devices, metal balls, plastic and bamboo balls, fragments in the form of arrowhead metal elements and many other metal and plastic products (pic.21).

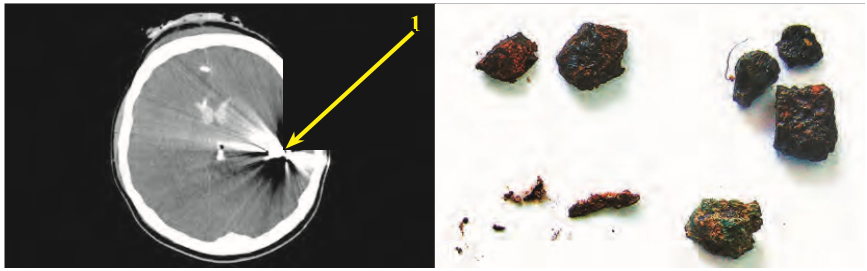


Fig. 21 Wounding projectiles that were removed during the provision of medical care.

- Computed tomography of the wounded with gunshot penetrating craniocerebral wound.
- Metallic fragments, removed from skull cavity during surgical intervention.

1 – Wounding projectile (fragment).

LOCALIZATION OF THE ENTRANCE WOUND FORMED BY THE WOUNDING PROJECTILE

In cases of gunshot wounds in the area of skull's arches and in cases of ricocheting wounds, the localization of the entrance wound on the vault of the skull is identical, and in parabasal - the entrance wounds on the soft tissues of the head correspond to the projection of the base of the skull. Typically, the following types of localization of the entrance wound are distinguished:

A. Wound of the skull's arches and cerebrum: *frontal, parietal, temporal, occipital, parietal temporal, frontal parietal, etc.;*
B. Parabasal wounds:
- **frontal:** *frontal orbital area, damage to the paranasal sinuses, injury of the eyeball;*
- **medium:** temporomandibular region;
- **posterior:** rear cranial fossa, craniospinal;

C. Ricocheting wounds: *frontal, parietal, temporal, occipital etc.*

Nature (type) of the wounding channel

In cases of wounds of skull's arches there are blind, transverse, and tangential wounding channels. In cases of wounds that are ricocheting, the wounding channels are formed by secondary wounding fragments (bone fragments) and can be *blind simple* and *blind radial.* In cases of parabasal wounds wounding channels can only be *blind (simple, radial, segmental and diametric).*
A. Wound of skull's arches:
- **blind:** *simple, radial, segmental, diametric.*
- **transverse:** *segmental, diametric.*
- **tangent**

B. Parabrasal wounds:
- **blind:** *simple, radial, segmental, diametric.*

C. Ricocheting wounds:
- **blind:** *simple, radial.*

LOCALIZATION AND THE SIDE OF LOCATION OF THE WOUNDING CHANNEL IN LOBES OF THE BRAIN

By localization of the wounding channel in the lobes of the brain wounding channels can be located in the frontal, temporal, parietal, occipital lobes, as well as in two or three lobes and in the hemispheres of the cerebellum.

By the side of the location of the wounding channel in the lobes of the brain wounding channel can be located in the right or left hemisphere, as well as in the right and left half of the brain at the same time.

TYPES OF FRACTURES OF THE SKULL IN GUNSHOT PENETRATING CRANIOCEREBRAL WOUNDS

The feature of the gunshot penetrating wounds of skull and cerebrum is the presence of various types of gunshot fractures depending on the kinetic energy of the wounding projectile, its trajectory, the localization of the entrance wound formed by the wounding projectile, the location of the wounding channel in the lobes of the brain and the type of the wounding channel.

There are the following types of fractures of the skull: linear, hollow, fragmentary, chipped.

In case of wounds of the skull's arches **(A)**, all types of fractures can be manifested. In cases of parabasal wounds **(B)**, as a rule, there are hollow fractures, and there may be linear fractures. In wounds that are ricocheting **(C)**, there are linear, fragmented, hollow, chipped fractures.

THE CHARACTERISTIC OF CERTAIN TYPES OF SKULL FRACTURES IN CASES OF GUNSHOT PENETRATING CRANIOCEREBRAL WOUNDS

Linear fracture is characterized by linear damage to the bone through its entire thickness: the outer plate, the spongy substance and the inner plate of the skull to a certain extent (Fig. 22).

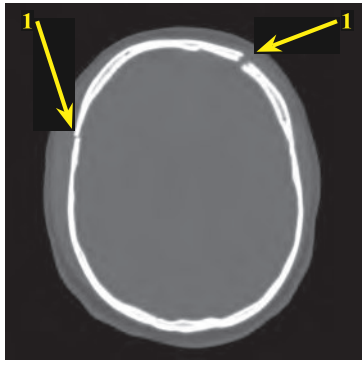


Fig. 22 Linear fracture of the skull. Computed tomography of the wounded.
1 - Linear fracture

Fragmented fracture is the damage of several bones of the skull in the form of linear fractures, which form large bone fragments with and without displacement in the cavity of the skull and outside (Fig. 23).

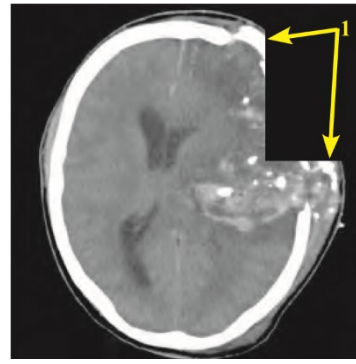


Fig. 23 Fragmented fracture in the form of three big bone fractures with displacement of front and posterior fractures outside. Computed tomography of the wounded

1 - Fragmented fracture

Chipped fracture is a local damage to the skull in the form of multiple small bone fragments, with a slight displacement of them into the cavity of the skull and outside (Fig. 24).

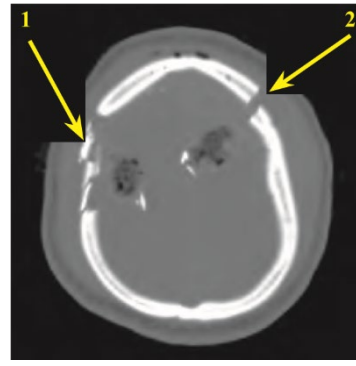


Fig. 24 Fragmented and chipped fractures of the skull. Computed tomography of the wounded.

1 - Chipped fracture; **2** - Fragmented fracture.

Hollow fracture is characterized by the formation of a rounded form with uneven edges of the defect of the skull in the place of action on him of the wounding projectile and by the formation of bone fragments from several in number sometimes, numerous with the implementation of them into the cavity of the skull on different depth (Fig. 25).

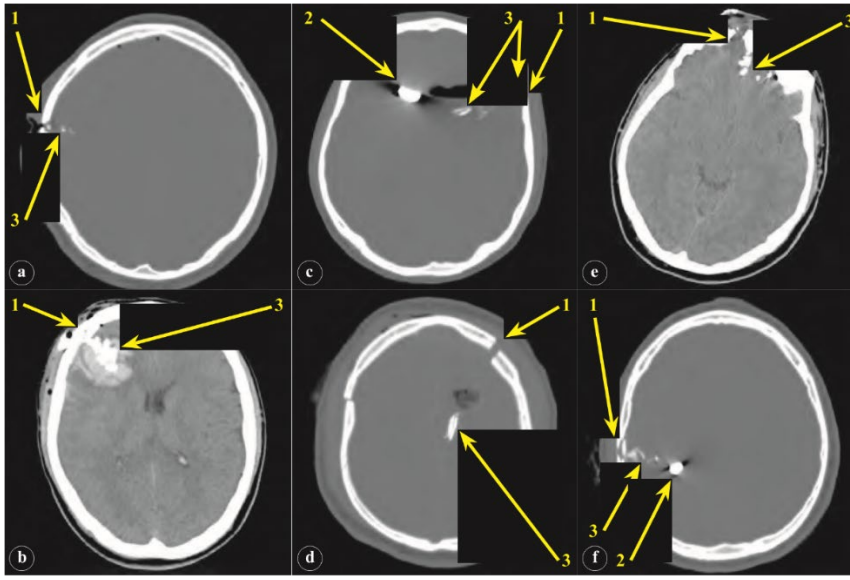


Fig. 25 Hollow fractures of the skull. Computed tomographies of six different wounded patients.

a-b. The depth of bone fragments in the brain substance is up to 3 cm.
c-d. The depth of bone fragments in the brain substance is up to 8 cm.
e-f. The depth of bone fragments in the brain substance is up to 4,5 cm.

1 - hollow fracture; **2** - wounding projectile (fragment); **3** - bone fractures.

GUNSHOT PENETRATING WOUNDS OF SKULL'S ARCHES AND CEREBRUM (A)

A.1. Gunshot penetrating blind craniocerebral wounds

Blind gunshot penetrating wounds of skull and cerebrum include wounds, in which kinetic energy of the wounding projectile is enough for the damage of skull's arches soft tissues, the bones of skull's arches, dura mater, brain structures. In this case, the wounding projectile ends its advance in the cavity of the skull and is located at the end of the wounding channel (Fig. 26).

Gunshot penetrating blind craniocerebral wounds by the depth and type of the wounding channel are divided into:

A.1.1 Simple;

A.1.2. Radial;

A.1.3 Segmental;

A.1.4. Segmental dual channel with internal ricocheting wounding projectile and continuation of segmental wounding channel into a simple or radial in other trajectory;

A.1.5. Segmental dual channel with internal ricocheting with bone fragments and two wounding channels, one of which is segmental: formed by a wounding projectile, the second - by bone fragments, ricocheting into the cavity of the skull by a simple or radial channel;

A.1.6. Diametric.

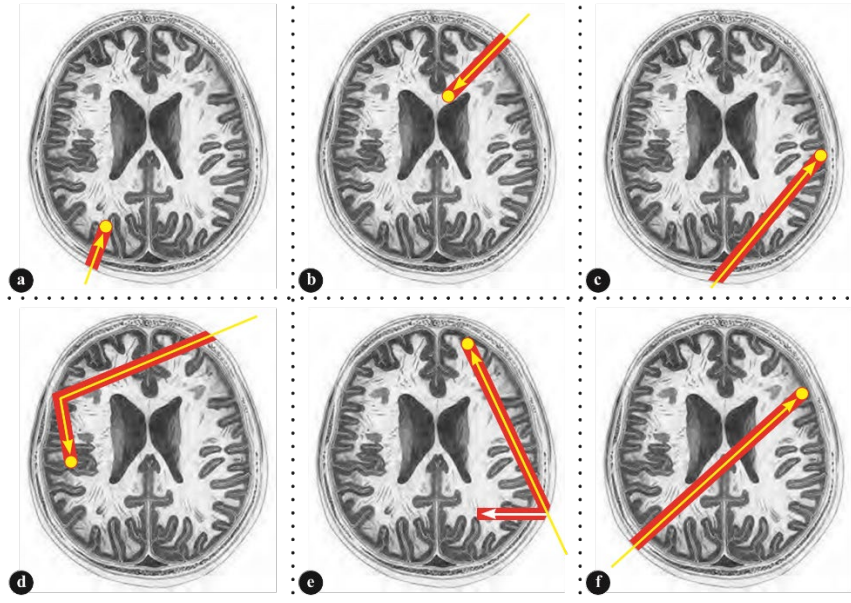


Fig. 26 Types of the wounding channels in cases of penetrating blind wounds of skull and cerebrum.

a. Simple.
b. Radial.
c. Segmental.
d. Segmental with internal ricocheting.
e. Segmental dual channel with internal ricocheting with bone fragments and two wounding channels, one of which is formed by a wounding projectile, the second - by bone fragments, ricocheting into the cavity of the skull by a radial channel;
f. Diametric.

IMPORTANT INFORMATION RELATED TO THE UNDERSTANDING OF THE MECHANISM OF WOUND, THE FORMATION OF THE DIAGNOSIS OF GUNSHOT PENETRATING CRANIOCEREBRAL WOUNDS

The main pathological formation of gunshot penetrating craniocerebral wounds is the wounding channel. The result and distinguishing features of surgical treatment depend on its localization in the substance of the brain, its extent and its prevalence in all directions (corresponding to the massiveness of brain damage). In this regard, special attention must be paid to the characteristics of the wounding channel in the diagnosis.

The wounding channel is a collection of destroyed tissues (smashed, necrotic) by a wounding projectile during its movement. Each channel has its beginning and its end. In the formulation of the diagnosis, the beginning of the wounding channel is indicated by the word "from" and the end of the wounding channel – by the word "to". This gives full clarity in determining the area of brain injury.

Indication in the diagnosis of penetration distance of bone fragments from the gunshot fracture in the substance of the brain, as well as their number - an important component in the planning of the operation of primary surgical treatment of the craniocerebral wound. The main purpose of the operation is to remove necrotic tissues of the brain, as well as all bone fragments, which are the main sources of severe infectious processes of the damaged brain.

An indication in the diagnosis of the distance of the wounding projectile (fragment, ball) penetration from the gunshot fracture to the substance of the brain is important for solving the need for its removal.

A.1.1 Blind simple wounding channel

A blind simple wounding channel is a brain damage along the wounding projectile, in the distal part of which there is a wounding projectile. Such a wounding channel does not exceed 75% of the distance from any point of the spherical surface of the arch of the skull to the relative center of the brain (the length of the relative radius) in size. The wounding channel, foreign body and bone fragments are located in the same lobe of the brain. In fig. 27 – fig. 30 examples of such type of a gunshot craniocerebral wound are provided.

Clinical observation 12

Gunshot penetrating fragmentary blind simple craniocerebral wound is illustrated in Fig. 27.

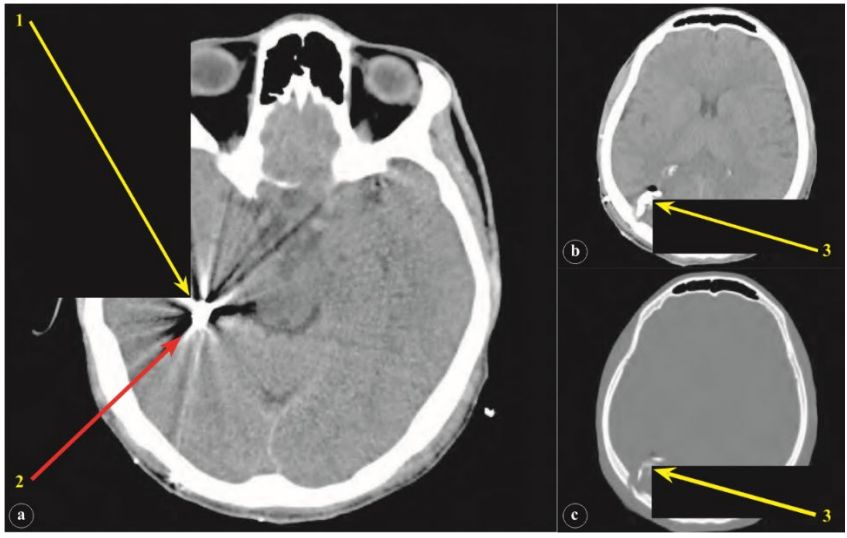


Fig. 27 Gunshot penetrating fragmentary blind simple craniocerabral wound: blind simple wounding channel in the right parietal lobe.

a-c. Computed tomography of the wounded.

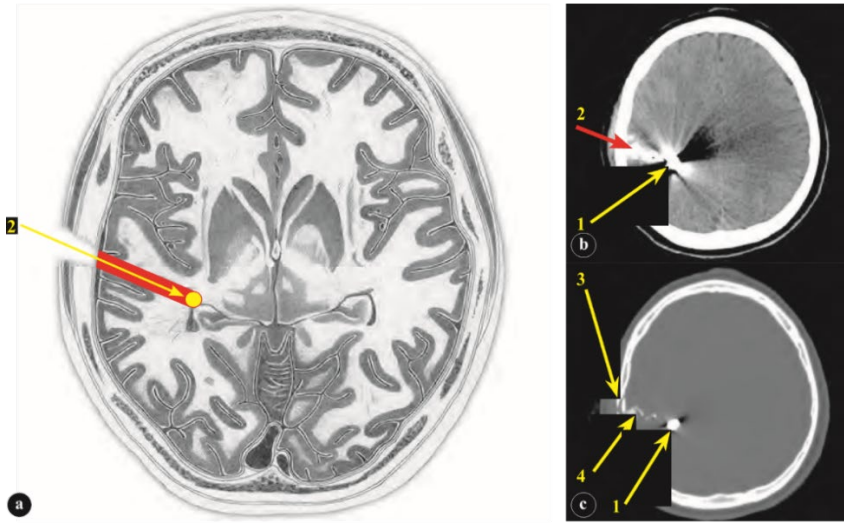
1 – Wounding projectile (fragment); **2** – Trajectory of the wounding projectile; **3** – Bone fractures.

An example of diagnosis formulation: *a gunshot penetrating fragmentary blind simple wound of the skull and cerebrum with the localization of the wounding channel, which begins from a wound of soft tissues and a hollow fracture in the right parietal region and ends in the right parietal lobe to a fragment at a depth of 7 cm and the depth of the advancement of bone fractures by a maximum of 4 cm from the hollow fracture (the number of bone fragments - 5).*

The removal of a fragment during initial surgical debridement may not be appropriate due to the large depth of advancement of the fragment.

Clinical observation 13

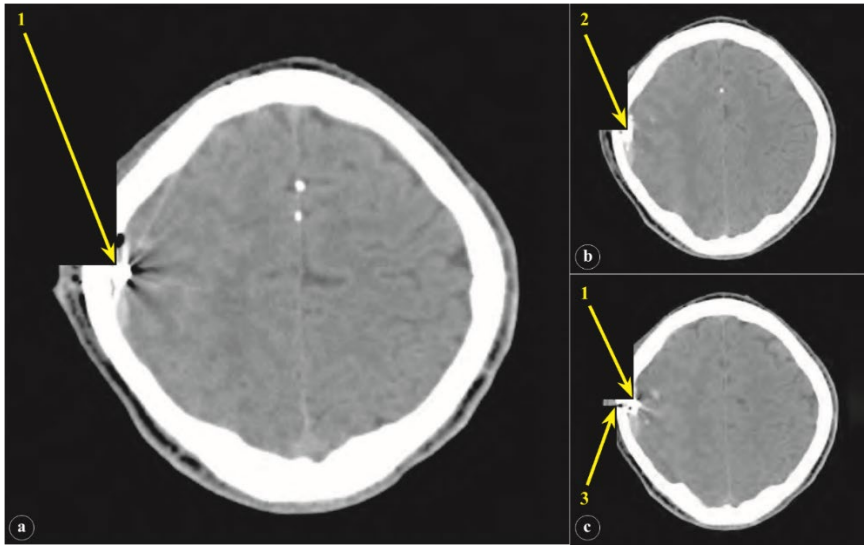
In fig. The inflammatory, penetrating, fragile, blind, simple, craniocereal injury is shown.



An example of the diagnosis: an inflammatory, fragmentary blind, simple, wound of the skull and the brain with the localization of the wound canal, which begins with a wound of soft tissues and a horn fracture in the right parietal region and ends in the right parietal lobe to a fragment at a depth of 6 cm with a depth of penetration of bone fragments by a maximum of 5 cm from the inner surface of the skull (number of bone fractures 6). When conducting the PCO, due to the large depth of the debris, it can not be removed.

Clinical observation 14

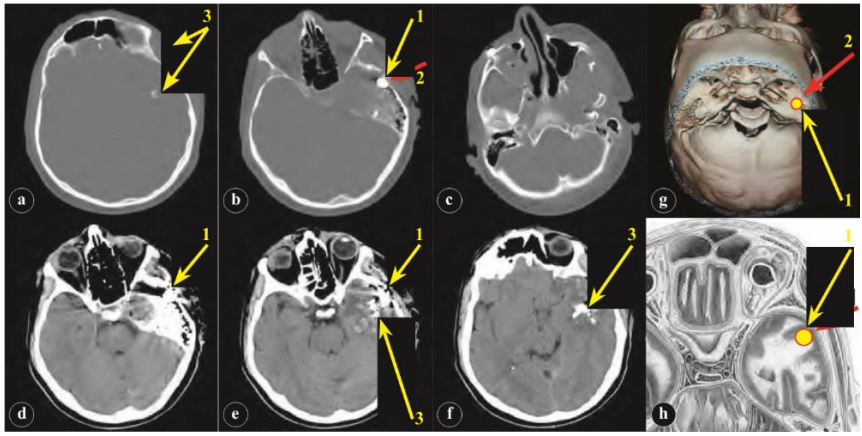
Fig. Illustrates a fire-penetrating fragile, blind, simple craniocerebral injury with a small depth of debris.



An example of the formulation of the diagnosis: a gunshot penetrating fragmentary blind, a simple injury to the skull and brain with the localization of the wound canal, which begins with a wound of soft tissues and a horn fracture in the right parietal region and ends in the right parietal lobe to the splint and bone fractures in depth their penetration into the parietal lobe at most 1.5 cm from the inner surface of the skull (the number of bone fragments 3). In the course of the PCO, due to the low depth of the incident, the fragment must be removed along with the bone fragments.

Clinical observation 15

The fire-penetrating fragmentary blind is a simple craniocereal injury (Fig.).



An example of the diagnosis: an inflammatory, infectious, glare, a simple, wounded cranium and brain wound with localization of the wound canal, which begins with a wound of soft tissues and a hollow fracture in the left temporal region and ends in the left temporal lobe of the bone fractures that penetrated the temporal lobe to the depth 4,5 cm maximum from the inner surface of the skull (the number of bone fragments 9), the depth of penetration into the cavity of the skull of the wound fragment - 1.5 cm. In the process of PCO deposition depth fragment can remove its before bone chips.

In gunshot penetrating fragile blind simple wounds of the skull and brain, the wounding projectile is more often located at the end of the wound canal, and the bone fragments - at the beginning or in the middle of the wound canal (observation clones 12 and 13) at a depth of 5 cm, less often bone chunks, along with wound shell (splint) are located directly in the substance of the brain under a hole fracture at a depth of 1.5 - 2 cm (see observation 14). Very rarely bone chips are located at the end of the wounded canal, and the splint is at its beginning. This is due to the fact that the fragment does not have sufficient kinetic energy (a wounding projectile of low kinetic energy) to move into the depth of the substance

of the brain after the transfer of its skull and stops in the region of the hollow fracture formed by it, whereas the bone fragments receive the energy transferred by the splint penetrate the substance of the brain to a depth of 5 cm (observation cl. 15).

A.1.2. Blind Radial Wounded Channel

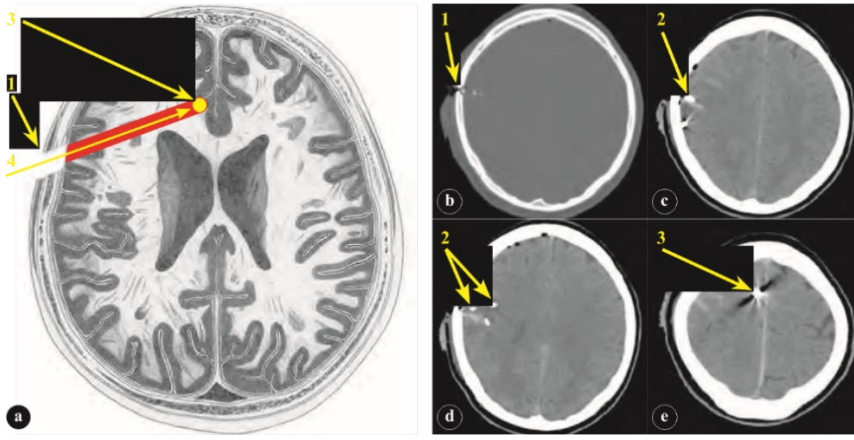
Blind Radial Wound Channel (Clinical Observation 16) is a firefire of damage to soft tissues of the skull and brain, in the distal part of which is a wounded projectile. The place of penetration of the wounding projectile into the cavity of the skull by location is greater than 75%, or equal to the relative radius of the circle of the skull in the axial projection, that is, it reaches the crescent-shaped apple or 3/4 of that distance, where it is located. A wavy channel with an alien body and bone fragments is located in the same fate of the brain.

A.1.3 Blind segmental wound channel

Blind segmental wound canal (Clinical Observation 17) is a channel formed following a wounded projectile located in one or more injured parts of the brain and is part of the segment in relation to the circle of the skull in the axial projection.

Clinical observation 16

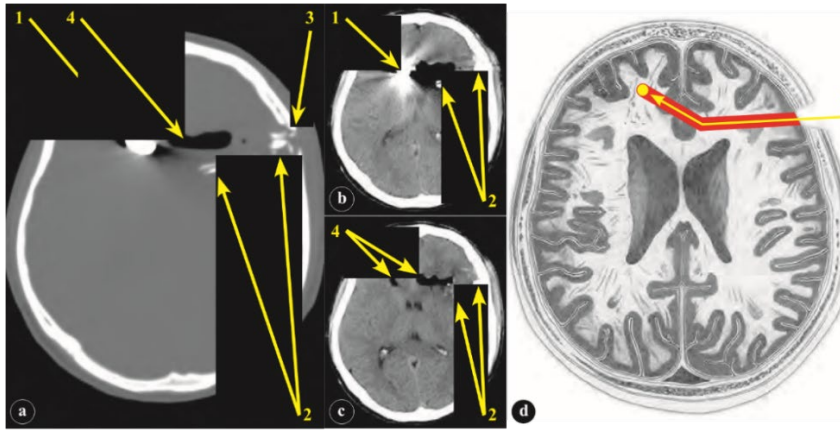
The fire-penetrating fragile, blind-wounded skull and brain with the formation of a radial wound canal are shown in Fig.



An example is the diagnosis: the fire-penetrating fragile wound of the skull and the brain with the localization of a blind radial wound canal, which begins with a wound of soft tissues and a hollow fracture in the right frontal and parietal region, and extends along the posterior sections of the right frontal lobe to the fragment in the area of the crescent appendix with a depth of penetration of bone fragments by a maximum of 4 cm from the hollow fracture in the right frontal and parietal region (the number of bone fragments 8), the depth of penetration of the splint in the cavity h erep - 7.5 cm. During the PCO, due to the large depth of the debris, it is not expedient to remove it.

Clinical observation 17

The fire-penetrating fragile, blind-wounded skull and brain with the formation of a segmental wound canal is shown in Fig.



Example of the diagnosis: an inflammatory penetrating fragile wound of the skull and the brain with the localization of a blind segmental wound canal, which begins with a wound of soft tissues and a horn fracture in the frontal bone to the left, extends to the left and right frontal lobes to the splint in the middle part of the right frontal lobe and the depth of penetration of bone fragments by a maximum of 6 cm from the hollow fracture (the number of bone fragments 14), the depth of penetration into the cavity of the skull of the splinters - 11.5 cm.
In the NWF, due to the large depth of occurrence of the fragment it is not appropriate to remove it.

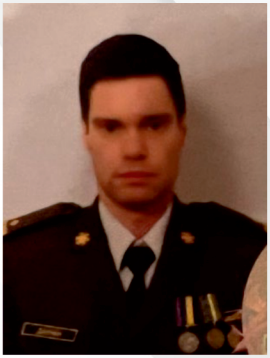
Edited by:

E.G. Pedachenko *Doctor of Medical Sciences, Professor, Honored Worker of Science and Technology of Ukraine, State Prize Laureate, Head of The State Romodanov Neurosurgery Institute, National Academy of Medical Sciences of Ukraine, Academician of the National Academy of Medical Sciences of Ukraine*	**Andre Grotenhuis,** *M.D., Ph.D. Professor of Neurosurgery, Radboud University Medical Centre, Nijmegen, The Netherlands Immediate Past-President, European Association of Neurosurgical Societies*
Authors: *Chief Neurosurgeon of the Ministry of Defense of Ukraine, Head of the Neurosurgery Clinic of the National Military Medical Clinical Center, colonel of the medical service, doctor of medical sciences* **A.O. Danchyn** *Head of the Department of Neurosurgery at the National Medical Academy of Postgraduate Education named after P.L. Shupik, corresponding member of the National Academy of Medical Sciences, doctor of medical sciences, professor* **M.E. Polischuk**	**Reviewers:** *Senior Resident of the Surgical Department, Clinic of Neurosurgery, National Military Medical Clinical Center lieutenant colonel of medical service* **G.O. Danchyn** *Deputy Chief of the Department of Military Surgery of the Ukrainian Military Medical Academy, doctor of medical sciences, professor, lieutenant-general of the medical service in retirement* **V.Y. Bilyy**
 Kyiv, 2018 Design, computer layout: S.O. Kutsenko 	ISBN: 978-966-1543-56-9X

Authors:

Chief Neurosurgeon of the Ministry of Defense of Ukraine, Head of the Neurosurgery Clinic of the National Military Medical Clinical Center, colonel of the medical service, doctor of medical sciences
A.O. Danchyn

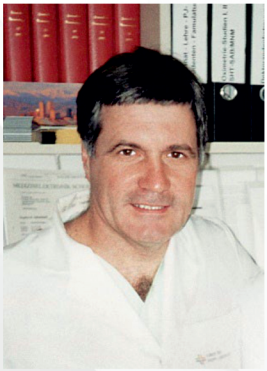
Head of the Department of Neurosurgery at the National Medical Academy of Postgraduate Education named after P.L. Shupik, corresponding member of the National Academy of Medical Sciences, doctor of medical sciences, professor
M.E. Polischuk



Senior Resident of the Surgical Department, Clinic of Neurosurgery, National Military Medical Clinical Center lieutenant colonel of medical service
G.O. Danchyn

Reviewers:

Deputy Chief of the Department of Military Surgery of the Ukrainian Military Medical Academy, doctor of medical sciences, professor, lieutenant-general of the medical service in retirement
V.Y. Bilyy



Professor of the Department of Military Surgery of the Ukrainian Military Medical Academy, Neurosurgeon of the highest category, Doctor of Medical Sciences, Professor, Honored Doctor of Ukraine
O.G. Danchin