

SURGERIES & CARDIOVASCULAR SYSTEM

Two vs Three-Point Fixation
in ZMC Fractures

Torsion Fields in
Cardiovascular Disease
Therapy

Whipple Procedure in
Trauma: A Case Report of...

Cirurgia de Whipple no
Trauma: Relato de Caso de.
..

Discovering Thoughts, Inventing Future

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Medicine, clinical research, public health, biomedical science and allied health disciplines.

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PREFACE

The Global Journal of Medical Research (GJMR) is pleased to present this issue, bringing together a curated collection of high-quality research papers that explore the latest advances in medical science and clinical practice.

This issue features research spanning topics including neurology, pharmacology & drug discovery, microbiology & pathology, radiology & diagnostics, gynecology, diseases, veterinary science, orthopedics, surgery & cardiovascular medicine, dentistry, nutrition, and interdisciplinary medical studies. Each paper has undergone a rigorous double-blind peer-review process to ensure clinical rigor and scientific originality.

We would like to express our sincere gratitude to the authors for entrusting their research with us, to the reviewers for their thorough and constructive evaluations, and to our readers for their continued engagement with the medical scientific discourse.

We hope that the research presented herein inspires further inquiry and contributes meaningfully to the advancement of medical knowledge and patient care.

The Chief Editor
Global Journal of Medical Research
Global Journals Organization

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Comparative Outcomes of Two-Point Versus Three-Point Microplate Fixation in Zygomaticomaxillary Complex Fractures

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PEER REVIEW

Double Blind

Abstract

Introduction: Zygomaticomaxillary complex (ZMC) fractures are common injuries due to the prominent position of the zygoma and involve multiple articulations (pentapod fractures), affecting facial contour, orbital function, and mastication. They occur mainly in young males, most often from road traffic accidents and assaults. CT is the diagnostic gold standard, and displaced fractures are treated with open reduction and internal fixation, with ongoing debate on optimal fixation points and microplate use to reduce morbidity.

Material & Methodology: A total of 56 patients meeting the inclusion criteria were enrolled in the study. The patients were randomly divided into two equal groups of 28 each. Group A underwent two-point fixation using microplates at the zygomaticomaxillary buttress and frontozygomatic region & Group B underwent three-point fixation using microplates at the zygomaticomaxillary buttress, frontozygomatic region, and infraorbital rim. Assessment was done on the bases of Intra-operative stability, Facial assessment, Inter-incisal mouth opening & Post-operative complications.

Result: We found that postoperative facial assessment was better in three-point fixation with minimal postoperative complications in three-point fixation. Based on this study, open reduction and internal fixation using three-point fixation using microplates is more beneficial for the management of zygomaticomaxillary complex fracture.

Discussion: The zygomaticomaxillary complex (ZMC) is crucial for facial structure and aesthetics and is frequently involved in maxillofacial trauma. In this study, 56 patients were randomly assigned to two-point or three-point fixation groups. Group B demonstrated superior facial aesthetics at 1 week ($p = 0.041$) and 12 weeks ($p = 0.05$), and significantly greater postoperative mouth opening at all follow-ups (1 week $p = 0.012$; 4 weeks $p < 0.001$). Intraoperative stability was comparable between groups ($p = 0.217$), and overall complication rates showed no statistically significant difference. Microplates provided stable fixation with improved aesthetics due to their low profile.

Internal fixation

open reduction and internal fixation

three-point fixation

two-point fixation

zygomaticomaxillary complex fracture

AI USE STATEMENT

No generative AI was used for analysis or results.

FUNDING

This study was funded by Encoll Corporation, the manufacturer of the Product included...

CONFLICT OF INTEREST

he review focuses on the Helicoll Skin Substitute product, manufactured by Encoll Corp. The author is a key employee of Encoll...

DATA AVAILABILITY

Not applicable for this article.

ETHICS

No ethics committee approval was required for this article type.

CONSENT

Not applicable for this article.

TRIAL REG.

Not applicable.

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METADATA CONTINUATION

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FULL FUNDING STATEMENT

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FULL CONFLICT OF INTEREST STATEMENT

he review focuses on the Helicoll Skin Substitute product, manufactured by Encoll Corp. The author is a key employee of Encoll Corp and has been involved in the development and commercialization of the product. This professional and financial relationship represents a potential conflict of interest. The lead author has over 40 years of experience in tissue regeneration and wound care research and commercialization.

ARCHIVAL RECORD

Comparative Outcomes of Two-Point Versus Three-Point Microplate Fixation in Zygomaticomaxillary Complex Fractures

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Discussion: The zygomaticomaxillary complex (ZMC) is crucial for facial structure and aesthetics and is frequently involved in maxillofacial trauma. In this study, 56 patients were randomly assigned to two-point or three-point fixation groups. Group B demonstrated superior facial aesthetics at 1 week ($p = 0.041$) and 12 weeks ($p = 0.05$), and significantly greater postoperative mouth opening at all follow-ups (1 week $p = 0.012$; 4 weeks $p < 0.001$). Intraoperative stability was comparable between groups ($p = 0.217$), and overall complication rates showed no statistically significant difference. Microplates provided stable fixation with improved aesthetics due to their low profile.

Keywords: Internal fixation, open reduction and internal fixation, three-point fixation, two-point fixation, zygomaticomaxillary complex fracture

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1. Introduction

The face is highly vulnerable to injury, and zygomaticomaxillary complex (ZMC) fractures are among the most common maxillofacial injuries due to the prominence of the zygomatic region¹. The zygoma, derived from the Greek word "Zygon," plays a critical role in facial structure, aesthetics, and function, with fractures documented as early as 1670 B.C². The zygoma articulates with frontal, maxillary, temporal, and sphenoid bones through five key processes, making ZMC fractures more accurately termed "pentapod fractures." ZMC fracture patterns depend on force direction and magnitude, with disruption occurring at weak articulations due to force transmission through its processes. ZMC fractures predominantly affect young adult males due to road traffic accidents, assaults, and falls³. CT imaging is the gold standard for diagnosis and treatment planning⁴.

Management remains controversial, but the goal is precise three-dimensional anatomical restoration⁵. Open reduction and internal fixation (ORIF) is the gold standard for unstable fractures^{6,7}. It is performed via intraoral access for the zygomaticomaxillary buttress and external incisions for the infraorbital rim and frontozygomatic suture⁸. Microplates offer advantages such as flexibility, minimal palpability, and reduced soft tissue disruption⁹.

This study aims to compare two-point versus three-point fixation using microplates to achieve stable fixation with minimal morbidity.

2. Material and Methodology

2.1. Source of Data

This study is a randomized controlled trial (RCT) with a parallel-group design, conducted in the Department of Oral & Maxillofacial

Surgery at NIMS Dental College & Hospital, Jaipur, for the management of zygomaticomaxillary complex fracture during the period of March 2024 to November 2025.

2.2. Sample of Data

The clinical study included 56 patients with zygomaticomaxillary complex fractures, selected based on specific inclusion criteria. Informed consent was obtained from all participants prior to enrolment. Ethical approval was granted under protocol no. IEC/P-552/224, on March 20, 2024. Statistical analysis was performed using Student's paired and unpaired t-tests.

2.3. Inclusion Criteria

1. Patient between 18 year to 50 years both male and female.
2. Patients having zygomatic complex fracture.
3. ASA I & II

2.4. Exclusion Criteria

1. Patients who are medically compromised and are not fit to undergo the surgery.
2. Patients with old facial fractures, who were referred for reconstructive surgery.
3. Patients not consenting for the study.
4. ZMC Fractures due to pathology.

2.5. Sample Size

- A total of 56 patients with zygomaticomaxillary complex fractures were included in the study.
- Data were collected using a standard proforma, and informed consent was obtained after explaining the study in the patients' language.
- Preoperative, intraoperative, and postoperative photographs were taken, and all necessary haematological investigations were performed.

They were randomly divided into two equal groups of 28 patients each:

- Group A (Two-point fixation): fixation at the zygomaticomaxillary buttress and frontozygomatic (FZ) area.
- Group B (Three-point fixation): fixation at the zygomaticomaxillary buttress, FZ area, and infraorbital rim.

2.6. Surgical Technique

After intubation, the eyes were protected with sterile gauze and ointment, and a throat pack was placed. Patients were draped following cleansing with 5% povidone iodine, and the oral cavity was irrigated with normal saline and povidone iodine. Fractures were accessed via intraoral and extraoral incisions, including existing lacerations, and infiltrated with 2% lignocaine with 1:80,000 adrenaline. Subperiosteal dissection exposed the fracture site and infraorbital neurovascular bundle. Fracture reduction was achieved using intermaxillary fixation or manual approximation.

Group A received internal fixation with 0.4–0.6 mm microplates at the zygomaticomaxillary buttress (ZMB) and frontozygomatic (FZ) region, while Group B also included the infraorbital rim.

Screw holes were drilled with a guiding sleeve to prevent thermal damage, and monocortical screws were placed. After fixation, the site was irrigated, maxillomandibular fixation released, and the wound closed in two layers with 3-0 Vicryl for deeper tissue and 5-0 Prolene for skin and mucosa.

2.7. Intraoperative Stability

The stability of the repositioned zygomaticomaxillary fracture was assessed intraoperatively by digital manual palpation to decide whether fixation devices were required (Figures 1 and 2).

2.8. Facial Assessment

- Assessment of malar asymmetry was performed using frontal and bird's-eye views.
- Assessment of malar asymmetry was carried out in accordance with the Holmes and Mathews classification.

“

Grade 1: Excellent cosmetic result, no malar asymmetry with any visible scar formation
 Grade 2: Good cosmetic result, malar asymmetry on careful inspection with very minimal scar formation
 Grade 3: Poor cosmetic result, noticeable malar asymmetry with minimal scar formation
 Grade 4: Gross malar asymmetry with noticeable scar formation [Figures 3 and 4].

2.9. Mouth Opening

Assessment was carried out using a Vernier calliper preoperatively and at 1-month and 3-months follow-up interval [Figures 5 and 6].



Figure 1. Group A – Intraoperative stability and fixation at fracture site

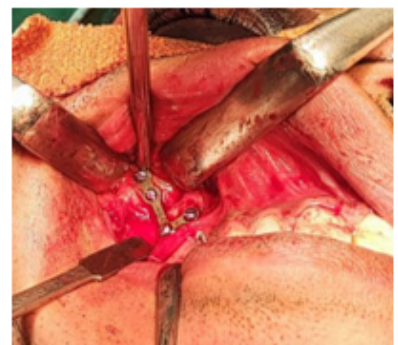
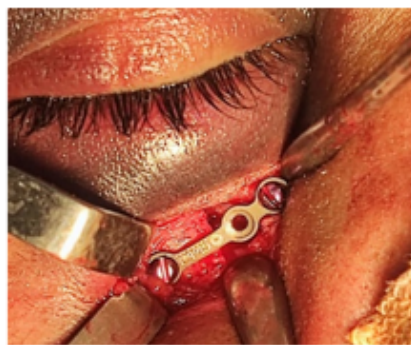


Figure 2. Group B – Intraoperative stability and fixation at fracture site



Figure 3. Group A – Facial assessment preoperative and postoperative



Figure 4. Group B – Facial assessment preoperative and postoperative

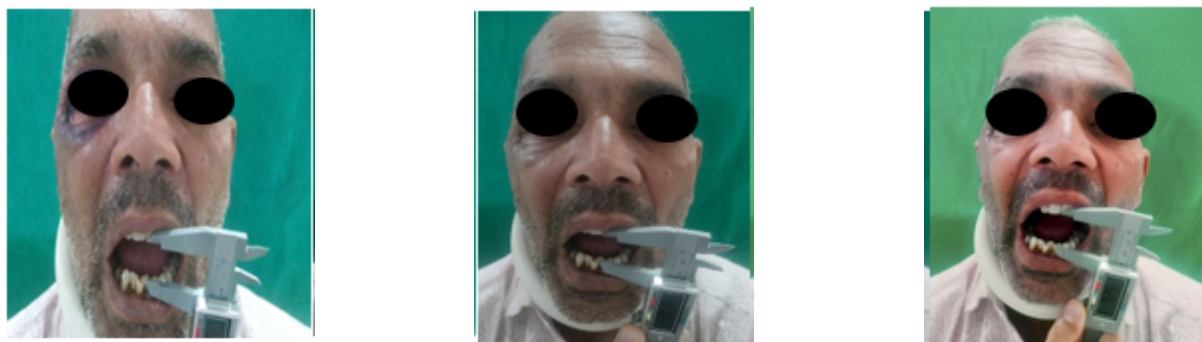


Figure 5. Group A – Interincisal mouth opening preoperative, 1 and 3 months



Figure 6. Group B – Interincisal mouth opening preoperative, 1 and 3 months

3. Results

After completion of the clinical study, measurements and data obtained from all patients were tabulated for statistical analysis, and observational data were derived following comparison of the two groups (Group A and B).

The treatment outcomes of two techniques were evaluated and compared with regard to the following variables:

1. Intra-operative stability
2. Facial assessment
3. Interincisal mouth opening
4. Post-operative complications

3.1. Intra-operative Stability

Intra-operative stability was observed in 19 (67.9%) patients in Group A and 23 (82.1%) patients in Group B, with no statistically significant difference between the groups ($p = 0.217$). Overall, 75% of patients demonstrated intra-operative stability.

3.2. Facial Assessment

Post-operative facial aesthetic outcomes at 1 week, 4 weeks, and 12 weeks using the Mann–Whitney U test. At the 1-week follow-up, Group A had a higher mean rank (31.52) compared to Group B (25.48). Since a lower mean rank indicates better facial aesthetics, Group B demonstrated superior facial aesthetic outcomes at 1 week, and the difference was statistically significant ($p = 0.041$).

At the 4-weeks follow-up, the mean ranks of Group A (29.00) and Group B (28.00) were almost identical, indicating that both groups had comparable facial aesthetic outcomes, with no statistically significant difference ($p = 0.788$).

At the 12-weeks follow-up, Group A again showed a higher mean rank (31.00) compared to Group B (26.00), indicating that Group B demonstrated better facial aesthetic outcomes at 12 weeks, with the difference reaching borderline statistical significance ($p = 0.05$).

3.3. Interincisal Mouth Opening

Post-operative mouth opening between Group A and Group B at 1 week, 4 weeks, and 12 weeks using the independent t-test. At 1 week, the mean mouth opening was 24.93 ± 3.23 mm in Group A and 26.93 ± 2.49 mm in Group B. The difference was statistically significant ($p = 0.012$), with Group B demonstrating greater mouth opening.

At 4 weeks, Group A showed a mean mouth opening of 30.96 ± 3.24 mm, while Group B showed 34.93 ± 2.49 mm. This difference was highly statistically significant ($p < 0.001$), again indicating better mouth opening in Group B.

At 12 weeks, the mean mouth opening increased to 36.11 ± 3.60 mm in Group A and 40.96 ± 2.55 mm in Group B. The inter-group difference remained highly statistically significant ($p < 0.001$).

3.4. Post-operative Complications

Post-operative complications at 1 week, 4 weeks, and 12 weeks using the Mann–Whitney U test. At the 1-week follow-up, Group A had a mean rank of 30.84, while Group B had a lower mean rank of 26.16, indicating that Group B experienced fewer and less severe complications, although the difference was not statistically significant ($p = 0.237$).

At the 4-weeks follow-up, mean ranks were 29.00 for Group A and 28.00 for Group B, showing no meaningful difference in complication severity between the two groups ($p = 0.739$).

At the 12-weeks follow-up, both groups demonstrated identical mean ranks (28.50), indicating that post-operative complications were comparable between the groups ($p = 1.00$).

4. Discussion

The zygomaticomaxillary complex (ZMC) is a critical component of the midfacial skeleton, contributing to facial structure, function, and aesthetic contour¹. ZMC fractures are among the most frequently encountered injuries in maxillofacial trauma, largely due to the prominent and exposed position of the zygomatic region, which increases its susceptibility to facial injury¹⁰.

Over the years, multiple management strategies have been described, ranging from closed reduction without fixation to open reduction with internal fixation using different fixation techniques.

In the present study, 56 patients were randomly allocated to two treatment groups: two-point fixation (Group A) and three-point fixation (Group B). Participants were aged 18–50 years.

The mean age was significantly higher in Group A (41.89 ± 11.16 years) compared with Group B (32.25 ± 6.65 years) ($p < 0.001$). Group A included 8 females and 20 males, whereas Group B comprised 7 females and 21 males. Overall, males accounted for 73.21% of cases, and gender distribution was comparable between the groups ($p = 0.763$). Similar male predominance has been reported in previous epidemiological studies of facial fractures¹¹.

Intraoperative stability after reduction was assessed by digital palpation to determine the requirement for fixation. Stability was observed in 19 patients in Group A and 23 patients in Group B, with no significant difference between groups ($p = 0.217$). Overall, 75% of cases demonstrated intraoperative stability. Improved stability with three-point fixation in complex fractures has been reported by Nasr et al.¹².

Facial aesthetic outcomes were evaluated using frontal and bird's-eye views, and malar asymmetry was graded according to the Holmes and Mathews classification. At 1 week, Group B demonstrated significantly better aesthetic results than Group A ($p = 0.041$). At 4 weeks, outcomes were comparable between groups ($p = 0.788$). At 12 weeks, Group B again shown superior results with borderline statistical significance ($p = 0.05$). Overall, three-point fixation yielded improved early and late aesthetic outcomes.

Maximum mouth opening was measured using a Vernier caliper. Group B demonstrated significantly greater mouth opening at 1 week ($p = 0.012$), 4 weeks ($p < 0.001$), and 12 weeks ($p < 0.001$), indicating superior functional recovery.

Postoperative complications, including pain, swelling, malar flattening, and wound infection, were graded on an ordinal scale. Although Group B showed fewer early complications, the differences were not statistically significant at 1 week ($p = 0.237$), 4 weeks ($p = 0.739$), or 12 weeks ($p = 1.00$). Both groups showed similar complication profiles at later follow-up.

Biomechanical studies suggest that microplates provide stability comparable to miniplates in maintaining fracture reduction and resisting displacement, although their smaller cross-sectional area results in higher stress distribution⁹. Their use is advantageous in regions with thin soft tissue coverage, such as the infraorbital rim, nasomaxillary region, and frontozygomatic area, where improved palpability and aesthetics are desirable¹².

The optimal number of fixation points in ZMC fractures remains debated and depends on fracture severity and displacement. Experimental studies by Davidson et al. demonstrated that three-point fixation at the frontozygomatic suture, infraorbital rim, and zygomaticomaxillary buttress provides maximum resistance to physiological forces. Similar findings were reported in a biophysical study by O'Hara et al.¹³.

maticomaxillary buttress provides maximum resistance to physiological forces. Similar findings were reported in a biophysical study by O'Hara et al.¹³.

5. Conclusion

The zygoma and maxilla constitute an essential part of the orbital framework and therefore play a significant role in the residual deformities that may persist following fracture management. Three-point microplate fixation demonstrated superior functional and aesthetic outcomes compared with two-point fixation in the management of zygomaticomaxillary complex fractures. Facial aesthetics, evaluated using the Holmes and Mathews grading system, showed improved cosmetic results at early and late follow-up, with better restoration of malar symmetry. Postoperative mouth opening was also significantly greater at all time points, reflecting enhanced functional recovery. Intraoperative stability and complication rates were similar between the groups. These findings are consistent with previous comparative and biomechanical studies indicating greater stability with fixation at three anatomical buttresses. While two-point fixation may be suitable for minimally displaced fractures, three-point fixation is recommended when optimal stability and aesthetic outcomes are desired.

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Analysis of the Medical Efficacy and Physical-Chemical Mechanism of Torsion Fields Generated by Scalar Waves in the Treatment of Cardiovascular and Cerebrovascular Diseases

Article Record

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Abstract

Due to the absence of rigorous mathematical modeling and extensive experimental validation, the applications of torsion fields generated by scalar waves (SWs)—such as superluminality, zero-point energy extraction and enhancement of the human energy field—remain in the hypothetical phase. The mainstream physics community has yet to recognize torsion field as a fundamental force; thus, current researches on the medical functionalities of scalar wave and torsion field still fall within the domain of medical fringe science. Building upon the precise modeling of the vacuum scalar wave equation and particle propagation mode, we derived a theoretical framework for the generation of artificial torsion fields via vortex electromagnetic fields of SWs. We further conducted a detailed analysis of the dynamic characteristics of torsion fields in thrombus removal, as well as the interaction between scalar waves and free electrons carried by erythrocytes. This work reveals two key insights: the medical utility of torsion fields generated by SWs in the treatment of cardiovascular and cerebrovascular diseases; and the essential relationship between vortex electromagnetic fields of SWs and torsion fields. Specifically, the torsion field is the acceleration field of local spatial tangential rotational motion induced by the vortex motion of the scalar wave vortex electromagnetic fields.

Quantum electrodynamics

scalar wave

torsion field

gravitational field

thrombus

AI USE STATEMENT

The authors confirm that no artificial intelligence (AI) tools were used in the writing or analysis of this study. All content is the original work of the authors.

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FULL DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

FULL ETHICS STATEMENT

Ethical approval was not required for this study because the research is based solely on anonymous, publicly available data and does not involve direct interaction with human participants.

ARCHIVAL RECORD

Analysis of the Medical Efficacy and Physical-Chemical Mechanism of Torsion Fields Generated by Scalar Waves in the Treatment of Cardiovascular and Cerebrovascular Diseases

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Abstract

Due to the absence of rigorous mathematical modeling and extensive experimental validation, the applications of torsion fields generated by scalar waves (SWs)—such as superluminality, zero-point energy extraction and enhancement of the human energy field—remain in the hypothetical phase. The mainstream physics community has yet to recognize torsion field as a fundamental force; thus, current researches on the medical functionalities of scalar wave and torsion field still fall within the domain of medical fringe science. Building upon the precise modeling of the vacuum scalar wave equation and particle propagation mode, we derived a theoretical framework for the generation of artificial torsion fields via vortex electromagnetic fields of SWs. We further conducted a detailed analysis of the dynamic characteristics of torsion fields in thrombus removal, as well as the interaction between scalar waves and free electrons carried by erythrocytes. This work reveals two key insights: the medical utility of torsion fields generated by SWs in the treatment of cardiovascular and cerebrovascular diseases; and the essential relationship between vortex electromagnetic fields of SWs and torsion fields. Specifically, the torsion field is the acceleration field of local spatial tangential rotational motion induced by the vortex motion of the scalar wave vortex electromagnetic fields.

Keywords: *Quantum electrodynamics, scalar wave, torsion field, gravitational field, thrombus*

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1. Introduction

Traditional technologies of transverse electromagnetic field (TEMF) for treating cardiovascular and cerebrovascular diseases primarily focus on the regulatory effects of physical therapies or bioactive substances (e.g., endothelin-1, nitric oxide) on vascular endothelial cells and blood circulation, with underlying mechanisms encompassing techniques such as TEMF stimulation, biofeedback, and microcurrent modulation[1–5]. EMF technology can act on vascular endothelial cells to promote nitric oxide release, thereby facilitating peripheral vasodilation and reducing blood flow resistance. The biofeedback module enables real-time monitoring of users' heart rate variability, balancing sympathetic and parasympathetic neural activities by modulating autonomic nervous function. Microcurrent stimulation can influence local tissue metabolism, accelerate lactic acid clearance, and enhance cell membrane stability.

Typically, the amplitude of electromagnetic longitudinal waves (scalar waves, SWs) is considerably smaller than that of the source transverse electromagnetic waves (TEM waves) generating them[6], thus they are often neglected. However, in certain scenarios—such as the near-field region—existing Maxwell's equations fail to fully characterize their electromagnetic properties, necessitating the consideration of SWs[7,8]. Substantial SWs can be generated when two coherent, out-of-phase TEM waves interfere[9,10]. The vortex electromagnetic field of SWs gives rise to a unique force field known as the torsion field[11–16]. While the static torsion field

exhibits extremely weak intensity (approximately 10^{27} times weaker than gravitational force), its dynamic intensity is substantially enhanced[17]. Torsion fields possess properties including superluminal propagation, non-shielding, zero-point vacuum energy extraction, and memory effects [18], and their potential and practical applications in medicine have gained widespread recognition and attention [19–23].

Nevertheless, due to the absence of rigorous wave equations and particle propagation model[24], applied researches of torsion fields generated by SWs on energy medicine has encountered technical bottlenecks, such as optimizing energy intensity and therapeutic frequencies. Consequently, many scholars have questioned the efficacy and reliability of scalar wave and torsion field therapy[25]. Additionally, conventional perspectives maintain that generating pure torsion fields generated by SWs is highly challenging, requiring precise control of the phase difference between two source waves to the picosecond level, stable interference point spatial conditions, and mitigating environmental noise, metal reflections, and geomagnetic disturbances. Even minimal phase drift can cause SWs to collapse into ordinary TEM waves, resulting in the loss of all unique properties.

As a result, current researches on torsion fields generated by SWs remain within the realm of fringe science, and no clear consensus has been established in authoritative medical literature regarding their medical functions and physicochemical mechanisms in treating cardiovascular and cerebrovascular diseases. By constructing

accurate models of the vacuum scalar wave equation and particle propagation, we aim to derive a theoretical framework for torsion fields generated by SWs and elucidate their intrinsic connections to mass and gravitational field. The development of these novel theoretical models may provide new tools and methodological approaches for analyzing the medical efficacy and physicochemical mechanisms of torsion fields generated by SWs in cardiovascular and cerebrovascular disease treatment.

2. The essence of electromagnetic fields

Both torsion field and SW wave are associated with spin effects. The torsion field stems from spacetime distortion [11], whereas SW waves originate from vortex electromagnetic fields [6]. Thus, torsion fields are closely related to SW waves, and investigating torsion fields necessitates a prior clarification of the essence of electromagnetic fields.

From the law of total current [26], the electromagnetic field $\vec{E}/\vec{B}$ in a conductor can be expressed as

$$\begin{aligned} \frac{1}{\mu\epsilon} \nabla \times \vec{B} &= \frac{\partial \vec{E}}{\partial t} + \frac{\sigma}{\epsilon} \vec{E} = \frac{\partial \vec{E}}{\partial t} + \frac{1}{\epsilon} \vec{J} = \frac{\partial \vec{E}}{\partial t} - \frac{\rho}{\epsilon} \vec{V}_e \\ &= (\vec{V}_e \cdot \nabla) \vec{E} - (\nabla \cdot \vec{E}) \vec{V}_e - (\vec{E} \cdot \nabla) \vec{V}_e + (\nabla \cdot \vec{V}_e) \vec{E} \quad (1) \\ &= \nabla \times (\vec{E} \times \vec{V}_e). \end{aligned}$$

Thus, it follows from Eq. (1) that

$$\frac{1}{\mu\epsilon} \vec{B} = -\vec{V}_e \times \vec{E}. \quad (2)$$

By synthesizing Eqs. (1) and (2), it is evident that the law of total current embodies a fundamental implication of the electromagnetic field: the relativistic effect of the propagation velocity of the electric field through positive charges (holes) in the conductor—specifically, the moving velocity of the electric field, $-\vec{V}_e$ —is converted into the magnetic field within the conductor, which aligns with the principle that a moving electric field generates a magnetic field [27].

Employing the same analytical approach, Faraday's Law of Electromagnetic Induction [26] yields that

$$\begin{aligned} \nabla \times \vec{E} &= -\frac{\partial \vec{B}}{\partial t} = (\vec{V}_B \cdot \nabla) \vec{B} \\ &= -(\nabla \cdot \vec{B}) \vec{V}_B - (\vec{B} \cdot \nabla) \vec{V}_B + (\nabla \cdot \vec{V}_B) \vec{B} + (\vec{V}_B \cdot \nabla) \vec{B} \\ &= \nabla \times (\vec{B} \times \vec{V}_B). \quad (3) \end{aligned}$$

Then, according to Eq. (3), we have

$$\vec{E} = -\vec{V}_B \times \vec{B}, \quad (4)$$

By synthesizing Eqs. (3) and (4), it is evident that Faraday's law of electromagnetic induction embodies another fundamental implication of the electromagnetic field: the magnetic field within the conductor is converted into an electric field in the conductor via the relativistic effect of the magnetic field's velocity vector $\vec{V}_B$ —specifically, a moving magnetic field generates an electric field [28].

In Eq. (4), $\vec{V}_B$ serves as both the wave velocity of electromagnetic transverse waves [26] and the velocity of magnetic field motion [28]. According to the principle of duality, the component $-V_{ez}$ of $-\vec{V}_e$ along the electromagnetic field propagation direction z is not

only the velocity at which positive charges propagate the electric field (or the velocity of the electric field itself) [10], but should also correspond to the wave velocity of some form of wave. It is hypothesized that while the TEM waves $\vec{E}_t/\vec{B}_t$ propagate along the z -direction within the conductor, there exists a type of electromagnetic longitudinal waves, i.e. SWs $\vec{E}_z/\vec{B}_\theta$ that propagates along the same z -direction with frequency ω_P and wave velocity V_{ez} [29].

Eq. (4)—which is associated with Faraday's law of electromagnetic induction for the TEM waves $\vec{E}_t/\vec{B}_t$ —can be expressed in terms of the electromagnetic scalar potential φ and magnetic vector potential $\vec{A}$ as follows [26]

$$\begin{aligned} \vec{E}_t &= -\nabla\varphi - \frac{\partial \vec{A}_t}{\partial t} \\ &= -\vec{V}_B \times (\nabla \times \vec{A}_t) \\ &= -j\vec{k}\varphi + j\vec{A}_t\omega \\ &= -j\vec{k}(\vec{V}_B \cdot \vec{A}) + j\vec{A}_t(\vec{k} \cdot \vec{V}_B) \\ &= -j\vec{k}(\vec{V}_B \cdot \vec{A}) + j\vec{A}_t\omega, \end{aligned}$$

which gives that

$$\varphi = \vec{V}_B \cdot \vec{A} = V_B A_z. \quad (5)$$

In accordance with the Lorenz gauge condition applicable to metallic conductors [26], we can obtain

$$\nabla \cdot \vec{A} = -\mu\epsilon \frac{\partial \varphi}{\partial t} = \mu\epsilon j\omega_P V_B A_z = \frac{j\omega_P A_z}{V_{ez}}.$$

Thus, it follows that

$$\frac{1}{\mu\epsilon} = V_{ez} V_B. \quad (6)$$

Eq. (6) reveals a constraint relation between $-\vec{V}_{ez}$ (the propagation velocity of the electric field of TEM waves in the conductor medium, i.e., the wave speed of SW waves) and $\vec{V}_B$ (the velocity of magnetic field motion, i.e., the wave speed of TEM waves): the product of the two quantities does not exceed the square of the speed of light in the conductor. For typical metallic conductors [30], we can obtain that

$$V_{ez} \sim 10^{10} \text{ m/s} \gg V_B = \sqrt{\frac{2\omega}{\mu\sigma}} \sim 10^6 \text{ m/s}, \quad (7)$$

which implies that the wave velocity V_{ez} of the SW propagating within the conductor could be superluminal.

3. The particle propagation mode for SWs

When two coherent light waves (termed "source light waves") with identical frequency, equal amplitude, opposite propagation directions, and a phase difference of π are superposed in a vacuum, a pair of vacuum scalar waves $\vec{B}_z/\vec{E}_\theta$ are generated [6]. Upon superposition, the resultant TEM fields $\vec{B}_t/\vec{E}_t$ vanish, creating the illusion of energy disappearance. However, according to the Aharonov-Bohm effect [31], this process merely corresponds to the extinction of the TEM waves—the magnetic vector potential $\vec{A}_\theta$ and electromagnetic scalar potential φ_θ in the vacuum do not cease to exist, but instead transform into the SWs [6].

By analogy with the electromagnetic fields in conductive media, the electromagnetic fields of vacuum SWs $\vec{B}_z/\vec{E}_\theta$ should also satisfy

electromagnetic conversion formulas shown as Eqs. (2) and (4). We thus hypothesize

$$\vec{E}_\theta = -V\vec{e}_R \times \vec{B}_z, \quad (8)$$

$$\frac{1}{\mu_0\epsilon_0}\vec{B}_z = V\vec{e}_R \times \vec{E}_\theta. \quad (9)$$

Here, V denotes the propagation velocity of the electromagnetic field associated with the vacuum SW, and should also correspond to the velocity at which a charge or particle propagates the electromagnetic fields [10]. Given the absence of charges in a vacuum, V must therefore represent the magnitude of the absolute velocity of the propagation particle of the SWs $\vec{B}_z/\vec{E}_\theta$ relative to the vacuum medium.

The particle propagation mode for the vacuum SWs $\vec{B}_z/\vec{E}_\theta$ is illustrated in Fig. 1 [18]. To uphold the conservation of angular momentum within this model, it is hypothesized that the propagating particles of the SWs consist of two left-handed neutrinos undergoing counter-rotating large-helical revolution, with a phase difference of π . The spin velocity of the left-handed neutrinos equals the speed of light, and both follow left-handed large-helical trajectories along the forward axis, with their axial velocity V_z also matching the speed of light. Since neutrinos possess mass, their tangential rotational velocity V_θ cannot exceed the speed of light [32]. By assuming that the mechanism of neutrinos rotating around the SWs' core is analogous to that of a ground-state electron orbiting the hydrogen nucleus [33], we can derive

$$V_\theta = \frac{C}{137}. \quad (10)$$

From Ref. [10], the frequency of the helical motion of scalar wave neutrinos, denoted as ω_p , corresponds to the frequency of the vacuum SWs $\vec{B}_z/\vec{E}_\theta$ and can be expressed as

$$\omega_p = j\frac{1}{\tau_2} = j\frac{\omega^2\epsilon_0}{\sigma_0} = 1.129 \times 10^{31} \text{ Hz}. \quad (11)$$

Accordingly, the step length of the helical motion of their propagation particle (neutrino) can be expressed as

$$\lambda = C\tau_2 = 2.654 \times 10^{-25} \text{ m}. \quad (12)$$

Herein, τ_2 denotes the vortex decay period of the vortex electric field $\vec{E}_\theta$, ω represents the frequency of the source light waves that generate the SWs, and σ_0 and ϵ_0 are the vacuum conductivity and vacuum permittivity, respectively.

Consequently, the energy ratio of $\vec{B}_z/\vec{E}_\theta$ to the source light waves can be expressed as

$$\frac{E_P}{E_T} = \frac{\hbar\omega_p}{\hbar\omega} = \frac{10^{31} \text{ Hz}}{10^{13} \text{ Hz}} = 10^{18}, \quad (13)$$

which implies that, in addition to the energy contribution E_T , the SWs $\vec{B}_z/\vec{E}_\theta$ must acquire a substantial amount of additional free energy from the zero-point vacuum field [10, 16]. The free energy acquisition mechanism of $\vec{B}_z/\vec{E}_\theta$ is associated with the local spatial vortex motions of the SW-propagating particles (neutrinos), where the vortex motion acts as the fundamental unit of energy and a bridge linking visible matter to invisible energy [18]. This vortex motion enables the extraction of zero-point vacuum energy via the coherent resonance effect between the torsion field they induce and the zero-point vacuum energy field [13, 14].

Given that SWs $\vec{B}_z/\vec{E}_\theta$ absorb a significant quantity of vacuum free energy, this energy—analogue to the local spatial curvature effect induced by massive objects and the gravitational field generated by spatial curvature—gives rise to a distinct spatial distortion effect within the helical interior of the SWs. This distortion manifests as a tangential distortion motion $V_{\theta 1}$ and a z-directional bending motion V_{z1} in the local space (see Fig. 2).

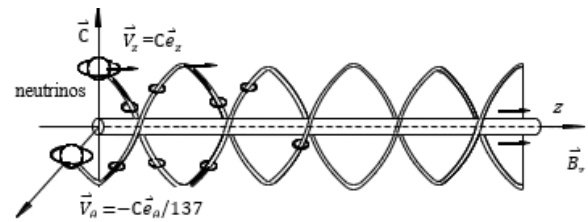


Figure 1. Particle propagation mode of vacuum SWs.

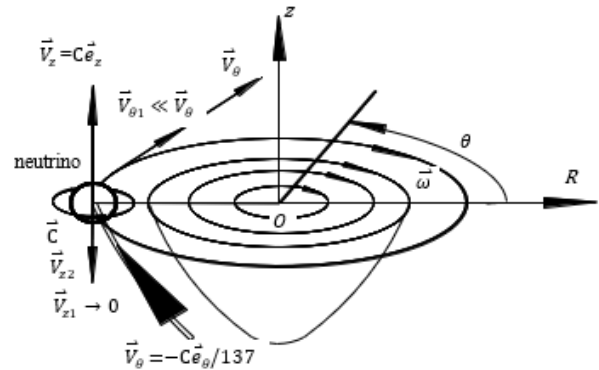


Figure 2. The helical motion of the neutrino around the core of the SWs.

To simplify the model, we assume the bending effect of the Earth in this local space corresponds to a z-directional bending motion V_{z2} , while neglecting the influence of macroscopic z-directional spatial expansion. Accordingly, the absolute equation of motion for the vacuum SW-propagating particle (neutrino) relative to the vacuum is expressed as

$$\vec{V} = C\vec{e}_z - \frac{C\vec{e}_\theta}{137} - V_{\theta 1}\vec{e}_\theta - V_{z2}\vec{e}_z. \quad (14)$$

Herein, $C\vec{e}_z$ denotes the linear motion of the SW neutrino at the speed of light along the z-direction, while $\frac{C\vec{e}_\theta}{137}$ corresponds to its tangential rotational motion. $V_{\theta 1}\vec{e}_\theta$ refers to the local spatial distortion motion induced by the scalar wave after it has absorbed a substantial amount of vacuum free energy, and $V_{z2}\vec{e}_z$ represents the z-direction bending motion of the Earth within this local space. Notably, $C\vec{e}_z$ and $\frac{C\vec{e}_\theta}{137}$ are the active motions of the scalar-wave neutrino, whereas $V_{z2}\vec{e}_z$ and $V_{\theta 1}\vec{e}_\theta$ are the passive motions of the SW neutrino that arise as a consequence of its following the spatial deformation.

4. The wave equations for SWs

As illustrated in Fig. 3, within the vacuum space, we establish a region $\mathbf{V}$ of the field point P centered at point O on the Earth's surface. In the source region $\mathbf{V}'$ (centered at the fixed source point O' adjacent to field region $\mathbf{V}$), there exist certain continuous, non-moving, and time-varying charges $\rho(\vec{r}', t)$ and a time-varying vortex current source $\vec{J}_\theta(\vec{r}', t)$ that is excited by external electromagnetic fields. These sources generate the SWs $\vec{B}_z/\vec{E}_\theta$ within the region $\mathbf{V}$.

Furthermore, a cylindrical coordinate system (R_1, θ, z) is established with an observer O_B as the origin on the Earth's surface. This coordinate system is employed to describe the propagation of the neutrino motion of $\vec{B}_z/\vec{E}_\theta$. When $\mathbf{V}'$ approaches zero and O_B coincides with O', the position vector $\vec{r}$ satisfies

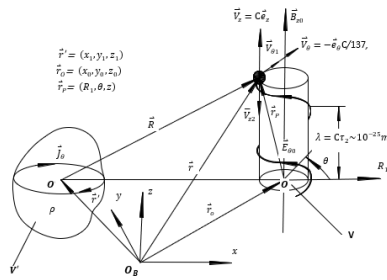


Figure 3. Distribution map of the source points and field points generating SWs in a vacuum.

$$\vec{r} = \vec{r}_P + \vec{r}_O \rightarrow \vec{R},$$

and

$$\begin{aligned} \frac{\partial R}{\partial t} &= \frac{\partial r}{\partial t} = \frac{\partial r_P}{\partial t} = \frac{\partial r_P}{\partial R_1} \frac{\partial R_1}{\partial t} + \frac{\partial r_P}{\partial \theta_1} \frac{\partial \theta_1}{\partial t} + \frac{\partial r_P}{\partial z} \frac{\partial z}{\partial t} \\ &= C - V_\theta - V_{\theta 1} - V_{z2}. \end{aligned} \quad (15)$$

Subsequently, in accordance with the relational formula between the scalar waves $\vec{B}_z/\vec{E}_\theta$ and $\vec{A}_\theta/\varphi_\theta$ [6], within region P, when the radial dimension $r = R = 10^{-3}\lambda \sim 10^{-28} \text{ m} \ll \lambda = C\tau_2 \sim 10^{-25} \text{ m}$ and $V_{\theta 1} \ll C$:

$$\begin{aligned} \vec{B}_z &= \nabla \times \vec{A}_\theta = \frac{\mu_0}{4\pi} \int_{V'} \nabla \times \left(\frac{\vec{J}_\theta}{R} \right) dV' \\ &= \frac{\mu_0}{4\pi} \int_{V'} -R^{-2} (\vec{e}_R \times \vec{J}_\theta) dV' \\ &= \vec{e}_R \times \frac{\mu_0}{4\pi} \int_{V'} -R^{-2} \vec{J}_\theta dV', \\ \vec{E}_\theta &= -\nabla \varphi_\theta - \frac{\partial \vec{A}_\theta}{\partial t} = -\frac{\partial \vec{A}_\theta}{\partial t} \\ &= \frac{\mu_0}{4\pi} \frac{\partial}{\partial t} \int_{V'} \left(\frac{\vec{J}_\theta}{R} \right) dV' \\ &= \frac{\mu_0}{4\pi} \frac{\partial R}{\partial t} \int_{V'} -R^{-2} \vec{J}_\theta dV' \\ &= (C - V_\theta - V_{\theta 1} - V_{z2}) \vec{e}_R \times \vec{B}_z \\ &\approx C \vec{e}_R \times \vec{B}_z. \end{aligned} \quad (16)$$

From Eqs. (16) and (17), the fundamental equations for $\vec{B}_z/\vec{E}_\theta$ in a vacuum are derived as follows [6]:

$$\frac{1}{\mu_0 \epsilon_0} \nabla \times \vec{B}_z = \frac{\partial \vec{E}_\theta}{\partial t} = \frac{\vec{E}_\theta}{\tau_2}, \quad (18)$$

$$\nabla \times \vec{E}_\theta = -\frac{\partial \vec{B}_z}{\partial t} = -\frac{\vec{B}_z}{\tau_2}, \quad (19)$$

whose plane wave solutions are presented as Eqs. (20) and (20.1):

$$\vec{E}_\theta = CB_{z0} \exp \left[j \left(\frac{\omega_P}{C} z - \omega_P t \right) \right] \vec{e}_\theta, \quad (20)$$

$$\vec{B}_z = B_{z0} \exp \left[j \left(\frac{\omega_P}{C} z - \omega_P t \right) \right] \vec{e}_z. \quad (20.1)$$

Fig. 4 depicts the wave patterns of $\vec{E}_\theta$ and $\vec{B}_z$, showing that $\vec{E}_\theta$ and $\vec{B}_z$ share the same phase angle and propagate along the positive z-axis at the phase velocity C. Eqs. (20) and (20.1) unveil the electromagnetic induction law governing the vacuum SWs $\vec{E}_\theta$

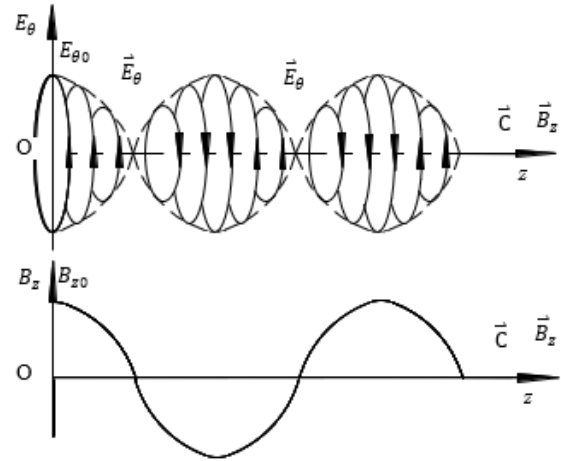


Figure 4. The wave propagation patterns of SWs $\vec{E}_\theta/\vec{B}_z$ in a vacuum.

and $\vec{B}_z$ —specifically, the scalar magnetic field $\vec{B}_z$ and the vortex electric field $\vec{E}_\theta$ are mutually convertible and propagate forward in a vacuum.

Within the vacuum, the local spatial vortex motion induced by $\vec{E}_\theta$ interacts with the zero-point vacuum energy field, forming a torsion field coherence (resonance) state. This state generates high-energy rays, neutrons, and high-energy particles at the vortex center of the scalar wave, while extracting zero-point vacuum free energy—accompanied by highly directional cold nuclear fusion [13]. This process embodies the mechanism by which SWs harness free energy from the zero-point vacuum energy field.

5. Torsion fields induced by vacuum SWs

Upon differentiating the left-hand side of Eq. (17), we obtain

$$\frac{\partial \vec{E}_\theta}{\partial t} = \frac{\partial}{\partial t} (E_\theta \vec{e}_\theta) = \frac{E_\theta}{\tau_2} \vec{e}_\theta - \frac{E_\theta}{\tau_2} \vec{e}_R, \quad (21)$$

while upon differentiating the right-hand side of Eq. (17), we obtain

$$\begin{aligned} \frac{\partial \vec{E}_\theta}{\partial t} &= C \vec{e}_R \times \frac{\vec{B}_z}{\tau_2} + C \vec{e}_\theta \times \frac{\vec{B}_z}{\tau_2} - V_\theta \vec{e}_\theta \times \frac{\vec{B}_z}{\tau_2} \\ &\quad - V_\theta \vec{e}_R \times \frac{\vec{B}_z}{\tau_2} - a_\theta \vec{e}_R \times \vec{B}_z - a_\theta \vec{e}_\theta \times \vec{B}_z \\ &\quad - g \vec{e}_R \times \vec{B}_z - g \vec{e}_\theta \times \vec{B}_z. \end{aligned} \quad (22)$$

In Eq. (22), $\frac{C}{\tau_2} \sim 10^{39} \text{ m/s}^2$ corresponds to the strong interaction scale. strong nuclear force field generated by the z-directional linear motion of the SW particle at the speed of light $C\vec{e}_z$, $\frac{V_\theta}{\tau_2} \sim 10^{37} \text{ m/s}^2$ undoubtedly represents the electromagnetic fields induced by its tangential subluminal rotational motion $V_\theta \vec{e}_\theta$, a_θ equaling $\frac{\partial V_{\theta 1}}{\partial t}$ denotes the acceleration field of the spatial tangential distortion motion induced by the vacuum SWs $\vec{B}_z/\vec{E}_\theta$ within their helical structure, namely the torsion field, and $g \sim 10 \text{ m/s}^2$ denotes the gravitational field acting on the SW neutrino. Eq. (22) appears to formally unify nuclear force, electromagnetic force, torsion field force, and gravitational force [34, 35]. An analysis of Eq. (22) reveals that, under ideal conditions, SWs can generate a torsion field with a magnitude comparable to that of the strong nuclear force. However, in the field of medical therapy, SW torsion fields do not require such enormous energy; only the torsion field corresponding to the

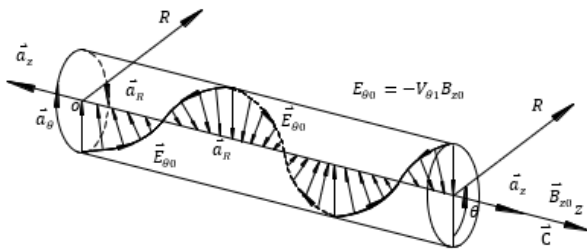


Figure 5. Artificial torsion fields generated by vacuum SWs.

local spatial tangential distortion motion $V_{\theta 1}$, induced by the vortex motion of SW particles, is necessary.

Based on Eqs. (21) and (22), when magnetism generates electricity, the electromagnetic fields adhere to the left-hand helix rule. The radial and tangential acceleration fields (i.e., the torsion fields $\vec{a}_R$ and $\vec{a}_\theta$) of the spatial tangential distortion motion $V_{\theta 1}\vec{e}_\theta$, induced by the vacuum SWs $\vec{B}_z/\vec{E}_\theta$, can be expressed as

$$\frac{E_\theta}{\tau_2}\vec{e}_\theta = -a_\theta\vec{e}_R \times \vec{B}_z, \quad (23)$$

$$\frac{E_\theta}{\tau_2}\vec{e}_R = a_\theta\vec{e}_\theta \times \vec{B}_z. \quad (24)$$

Meanwhile, based on Eq. (17), the electromagnetic conversion relation of the torsion-field-inducing SWs $\vec{B}_z/\vec{E}_\theta$ can be expressed as

$$\vec{E}_\theta = -V_{\theta 1}\vec{e}_R \times \vec{B}_z. \quad (25)$$

Projecting Eq. (25) onto the θ -direction as shown in Fig. 3 yields

$$-E_\theta = V_{\theta 1} \times B_z, \quad (26)$$

which indicates that the torsion-field-inducing SWs $\vec{B}_z/\vec{E}_\theta$ have a phase difference of 180° , i.e., $dE_\theta = -V_{\theta 1}dB_z$.

By combining Eqs. (23), (24), and (26), the torsion fields $\vec{a}_R$ and $\vec{a}_\theta$ generated by the vacuum SWs $\vec{B}_z/\vec{E}_\theta$ can be expressed as

$$\vec{a}_R = a_\theta\vec{e}_R = -\vec{E}_\theta \times \frac{\vec{B}_z}{B_z^2\tau_2} = \frac{1}{B_z^2}\vec{B}_z \times \frac{\partial\vec{E}_\theta}{\partial t}, \quad (27)$$

$$\vec{a}_\theta = a_\theta\vec{e}_\theta = -\vec{e}_\theta \frac{V_{\theta 1}}{\tau_2} = -E_\theta\vec{e}_R \times \frac{\vec{B}_z}{B_z^2\tau_2}. \quad (28)$$

Similarly, based on the relational Eqs. (16) and (17) between $\vec{B}_z/\vec{E}_\theta$ and $\vec{A}_\theta/\varphi_\theta$, when electricity generates magnetism, the electromagnetic conversion relation of the torsion-field-inducing SWs $\vec{B}_z/\vec{E}_\theta$ can also be expressed as $V_{\theta 1}^2\vec{B}_z = V_{\theta 1}\vec{e}_R \times \vec{E}_\theta$.

Employing the same analytical approach, it is found that when electricity generates magnetism, the electromagnetic fields follow the right-hand helix rule. The z -directional acceleration field of the local spatial curvature motion induced by $\vec{B}_z/\vec{E}_\theta$ —namely, the z -directional torsion field—can be expressed as

$$\vec{a}_z = a_\theta\vec{e}_z = \vec{e}_z \frac{V_{\theta 1}}{\tau_2} = \frac{(\vec{e}_R \times \vec{E}_\theta)}{B_z\tau_2}. \quad (29)$$

6. Dynamic analysis of thrombus removal induced by torsion fields

6.1. Negative mass induced by radial torsion field

According to the wave pattern of the vacuum SWs $\vec{B}_z/\vec{E}_\theta$ illustrated in Fig. 4, when magnetism induces electricity, the electromagnetic

field follows the left-hand screw rule, and $\frac{\partial E_\theta}{\partial t} < 0$ —meaning the vortex electric field E_θ decreases with time. Accordingly, the radial torsion field $\vec{a}_R$ associated with the spatial tangential distortion motion $V_{\theta 1}\vec{e}_\theta$ induced by $\vec{B}_z/\vec{E}_\theta$ can be expressed as

$$\vec{a}_R = a_\theta\vec{e}_R = -\frac{1}{B_z^2}\vec{B}_z \times \vec{e}_\theta \frac{\partial E_\theta}{\partial t} = -\frac{E_\theta}{B_z\tau_2}\vec{e}_R; \quad (30)$$

when electricity induces magnetism, the electromagnetic field obeys the right-hand screw rule, and $\frac{\partial E_\theta}{\partial t} > 0$ —meaning the vortex electric field E_θ increases with time. Accordingly, the radial torsion field $\vec{a}_R$ associated with the spatial tangential distortion motion $V_{\theta 1}\vec{e}_\theta$ induced by $\vec{B}_z/\vec{E}_\theta$ can be expressed as

$$\vec{a}_R = a_\theta\vec{e}_R = \frac{1}{B_z^2}\vec{B}_z \times \vec{e}_\theta \frac{\partial E_\theta}{\partial t} = -\frac{E_\theta}{B_z\tau_2}\vec{e}_R. \quad (31)$$

It is evident that regardless of whether electricity induces magnetism or magnetism induces electricity, the direction of the radial torsion field $\vec{a}_R$ generated by $\vec{B}_z/\vec{E}_\theta$ is as illustrated in Fig. 5: the radial torsion field $\vec{a}_R$ is an intense spiral centripetal acceleration field.

With reference to the definitions of relevant physical quantities in electrostatic fields [36], within a stationary spherical space $\mathbf{R}$, we define the gravitational field $\vec{a}$, gravitational potential φ_g , gravitational displacement vector $\vec{F}$, and global gravitational flux ϕ_g induced by a spherical object of mass M located at the space center O (with radius r_0 , density ρ , surface area S , and volume V , respectively) as follows (see Fig. 6):

$$\vec{a} = -\frac{GM}{r^2}\vec{e}_R \quad (31.1)$$

$$\varphi_g = \frac{-GM}{r}, \quad (31.2)$$

$$\vec{F} = \frac{1}{4\pi G}\vec{a} = -\frac{M}{4\pi r^2}\vec{e}_R, \quad (31.3)$$

$$\phi_g = \oint_S \vec{F} \cdot d\vec{S} = \oint_S -\frac{1}{4\pi G}\vec{a} \cdot d\vec{S} = \frac{M}{4\pi} \oint_S \frac{1}{r^2} dS = M. \quad (31.4)$$

Herein, G denotes the gravitational constant, and r is the radial distance from the center O of the spherical space $\mathbf{R}$. Eq. (31.4) implies that the essence of mass M lies in the total surface integral of the gravitational field $\vec{a}$ induced by it (i.e., the gravitational flux). Taking the cylindrical surface formed by the helical motion of SW neutrinos in Fig. 5 as the Gaussian surface, and assuming that the lateral surface area of this Gaussian surface is much larger than the area of its two end faces, the total Gaussian surface integral of the torsion field $\vec{a}_R$ induced by $\vec{B}_z/\vec{E}_\theta$ can be expressed as

$$\oint_S -\frac{1}{4\pi G}\vec{a}_R \cdot d\vec{S} = \oint_S -\frac{1}{4\pi G} \frac{V_{\theta 1}}{r^2\tau_2} dS = -\frac{1}{4\pi G} \frac{V_{\theta 1}}{r^2\tau_2} 2\pi RL = -M. \quad (31.5)$$

Herein, L denotes the thrombus length and R denotes its radius. When the SW is responsible for the mass reduction of the thrombus. Once the thrombus mass is reduced to zero, it enters a wave state and exits the human body at the speed of light. Concurrently, as the thrombus transitions into the wave state, the medical treatment mechanisms and approaches for cardiovascular and cerebrovascular thrombosis may undergo qualitative changes.

6.2. Coagulation motion of thrombus induced by tangential torsion field

It is evident that regardless of electromagnetic induction (whether electric fields generate magnetic fields or vice versa), the direction

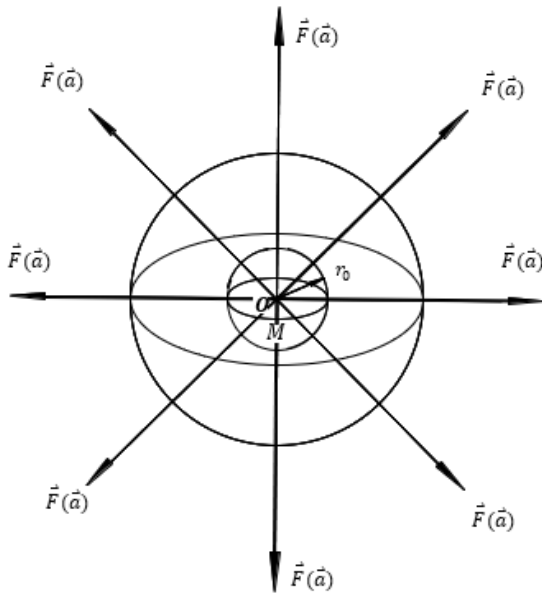


Figure 6. Gravitational field and displacement vector produced by a mass M .

of the tangential torsion field $\vec{a}_\theta$ induced by $\vec{B}_z/\vec{E}_\theta$ is illustrated in Fig. 5: the tangential torsion field $\vec{a}_\theta$ causes local space to rotate clockwise (when viewed from the positive to the negative direction of $\vec{B}_z$). Analogous to centrifugation techniques, $\vec{a}_\theta$ promotes the aggregation of thrombogenic factors derived from positively charged dysfunctional red blood cells in human blood, forming helical filamentous thrombus clusters. This process reduces thrombus volume and mitigates the challenges associated with thrombus management.

6.3. Directional guidance of thrombus removal by z-axis torsion field

According to Eq. (29), the z-directional bending acceleration field induced by the local spatial distortion motion triggered by $\vec{B}_z/\vec{E}_\theta$, namely the z-directional torsion field $\vec{a}_z$, can be expressed as

$$\begin{aligned}\vec{a}_z &= a_\theta \vec{e}_z = \vec{e}_z \frac{V_{\theta 1}}{\tau_2} = \frac{(\vec{e}_R \times \vec{E}_\theta)}{B_z \tau_2} \\ &= \frac{1}{B_z} \left(\vec{e}_R \times \frac{\partial \vec{E}_\theta}{\partial t} \right).\end{aligned}\quad (32)$$

As electricity induces magnetism, $\frac{\partial E_\theta}{\partial t} > 0$, meaning the vortex electric field E_θ increases with time,

$$\vec{a}_z = a_\theta \vec{e}_z = \frac{1}{B_z} \left(\vec{e}_R \times \frac{\partial E_\theta}{\partial t} \vec{e}_\theta \right) = \vec{e}_z \frac{V_{\theta 1}}{\tau_2}; \quad (33)$$

while as magnetism induces electricity, $\frac{\partial E_\theta}{\partial t} < 0$, meaning the vortex electric field E_θ decreases with time,

$$\vec{a}_z = a_\theta \vec{e}_z = \frac{1}{B_z} \left(\vec{e}_R \times \frac{\partial E_\theta}{\partial t} \vec{e}_\theta \right) = -\vec{e}_z \frac{V_{\theta 1}}{\tau_2}. \quad (34)$$

It is evident that the expression of the z-directional torsion field $\vec{a}_z$ induced by SWs $\vec{B}_z/\vec{E}_\theta$ still adheres to Newton's laws of motion. Its direction is either consistent with or opposite to the propagation direction of the scalar magnetic field $\vec{B}_z$ of the scalar wave, depending on the rate of change of the vortex electromagnetic

field E_θ . When the SW torsion fields target cardiovascular and cerebrovascular thrombi, the dominant motion of the thrombus driven by the z-directional torsion field $\vec{a}_z$ governs the direction of thrombus removal.

7. The interaction between vacuum SWs and red blood cells

The primary component of blood consists of red blood cells, and thrombus formation essentially arises from the adhesion of red blood cells. The surface of each healthy red blood cell carries a negative charge. With aging and the occurrence of metabolic abnormalities, the surface of pathological red blood cells becomes enveloped by a lipid membrane, which diminishes or abolishes their negative surface charge while augmenting the positive charge. This leads to electrostatic attraction between pathological and healthy red blood cells, culminating in the formation of what is known as a thrombus.

Mature red blood cells shed their nuclei and mitochondria to maximize the spatial capacity for hemoglobin, thereby optimizing their oxygen-transport function. They rely on anaerobic glycolysis to generate adenosine triphosphate (ATP) for energy supply. ATP is indispensable for all life processes. Fluctuations in the ATP/adenosine diphosphate (ADP) ratio are intricately linked to numerous pathways, including apoptosis, autophagy, and energy metabolism, and thus ATP/ADP ratio is frequently employed as one of the indicators for assessing cell viability[38]. When ATP is hydrolyzed into ADP and inorganic phosphate, energy is released to drive a multitude of intracellular biochemical processes, which in turn stimulates, balances, and enhances the energy of the organism's biological field, facilitating the restoration of health.

In the process of blood circulation, the most fundamental chemical reaction is electron transfer, which is mediated by hemoglobin. Hemoglobin molecules are, in fact, long chains formed by the linkage of amino acid molecules, each exhibiting identical left-handed chirality.

When a living organism receives the left-handed SW (carrying drug/nutrient information and zero-point vacuum energy) emitted by a SW generator, the scalar magnetic field B_L of the left-handed SW induces a left-handed eddy potential $\vec{E}_v$ channel along hemoglobin molecular chain (see Fig. 7) while delivering information and energy to cells. This left-handed $\vec{E}_v$ attracts left-spinning free electrons in the cell fluid to move left-handedly along hemoglobin chains, accelerating the dissociation of intracellular water molecules into H^+ and OH^- (the source of free electrons). This disrupts the intracellular ATP/ADP concentration balance, thereby accelerating the synthesis of ATP from ADP and inorganic phosphate, and decelerating ATP hydrolysis. The release of free electrons also stimulates the antioxidant activity of cells, increasing the ATP/ADP concentration ratio in red blood cells, promoting blood circulation, and maintaining the organism in a high-energy state (see Fig. 7).

When cells interact with the scalar magnetic field B_R of right-handed SWs, the organism generates B_R at the center of hemoglobin chains. The device regulates B_R to induce a right-handed $\vec{E}_v$ channel, which repels free electrons in the cell fluid. This accelerates the recombination of H^+ and OH^- into water molecules, thereby accelerating ATP hydrolysis into ADP and inorganic phosphate in red blood cells, while decelerating ATP synthesis. The ATP/ADP ratio in red blood cells decreases, blood circulation slows, and the organism enters a low-energy state.

The energy required for ATP synthesis is derived from three sources: food oxidation (in animal cells, fungi, and some bacteria), light energy capture (in plant cells and some bacteria), and zero-point

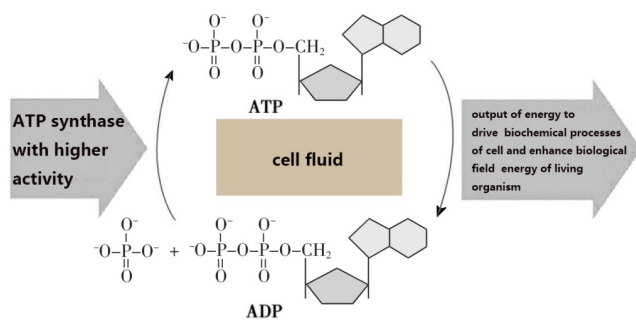


Figure 7. ATP/ADP mutual conversion in mitochondria of cells under the action of SWs.

vacuum energy supplied by scalar waves (applicable to both animal and plant cells).

From the above analysis, SWs are closely associated with normal blood circulation and thrombus formation. The quantity of free electrons provided by SWs not only directly determines thrombus size and concentration but also regulates the ATP/ADP ratio in red blood cells. Left-handed SWs supply free electrons to red blood cells, increasing their ATP/ADP ratio, accelerating blood circulation, and sustaining the organism in a high-energy state.

8. Conclusion

Based on the rigorous vacuum SW equations and particle propagation mode, we propose a theoretical model for the torsion fields generated by vacuum SWs, revealing their intrinsic connections to mass and gravitational field. The establishment of these novel torsion field theoretical models provides feasible solutions to bottleneck issues in the research on medical applications of torsion fields—such as the optimization of torsion field energy intensity and SW therapeutic frequency—while offering new tools and implementation approaches for analyzing the medical functions and physicochemical mechanisms of torsion fields generated by vacuum SWs in the treatment of cardiovascular and cerebrovascular diseases. Finally, we conduct a detailed analysis of the dynamic characteristics of thrombus removal by the torsion fields and the interaction between SWs and red blood cells.

The magnitude of the torsion field generated by vacuum SWs is correlated with the variation frequency and electromagnetic conversion efficiency of the SW electromagnetic field, i.e., the velocity of local spatial distortion motion induced by SWs within the helix. The theoretical expression of the torsion field generated by SWs still adheres to Newton's laws of motion: the direction of the z-axis torsion field is either parallel or antiparallel to the propagation direction of the SW, depending on the rate of change of the scalar electric field E_z , which dictates the direction of thrombus removal; the radial torsion field is a strong helical centripetal acceleration field that induces the mass-reduction process of thrombi; the tangential torsion field drives the rotation of local space inside the SW helix, leading to thrombus aggregation. The three torsion fields act as a precise micro-surgical scalpel, enabling non-invasive aggregation and removal of intravascular thrombi while delivering energy and information to living organisms and enhancing their bioenergetic fields.

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■ COMPETING INTERESTS

The authors declare no competing interests.

■ DATA AND MATERIALS AVAILABILITY

All data are available in the main text or the supplementary materials.

■ ETHICS DECLARATIONS

The study did not require ethical approval.

■ APPROVAL FOR ANIMAL EXPERIMENTS

Confirms that all experiments were performed in accordance with relevant named guidelines and regulations.

■ APPROVAL FOR HUMAN EXPERIMENTS

Confirms that all experiments were performed in accordance with relevant named guidelines and regulations.

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Translation of "Cirurgia de Whipple no Trauma: Relato de Caso de Lesão Complexa Por Arma de Fogo"

Article Record

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PEER REVIEW

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Abstract

Introduction: Firearm violence accounts for more than 70% of homicides in Brazil and represents a significant cause of years of potential life lost. Gunshot wounds to pancreaticoduodenal organs are rare (representing only 0.3% of abdominal traumas) and carry high morbidity and mortality rates. The literature recommends conservative treatment or primary repair for AAST grade 1–2 injuries, while more severe injuries (AAST 3–5) may require damage control strategies and, in selected cases, extensive resections such as pancreaticoduodenectomy (Whipple procedure).

Case Report: A 23-year-old male, victim of a thoracoabdominal gunshot wound, arrived at the emergency department with a Glasgow score of 5 and hemodynamic instability. He was intubated and underwent an emergency midline laparotomy.

The identified injuries were: 1. Transverse colon > 50% of the circumference (AAST grade 3); 2. Transfixing stomach injury (AAST grade 3); 3. Duodenum, D2 portion (AAST grade 3); 4. Head of the pancreas with distal bile duct rupture (AAST grade 5).

A damage control approach was chosen: primary suture of the colon, partial gastrectomy, and resection of the duodenum and pancreatic head, followed by vacuum-assisted closure (peritoneostomy). After 48 hours in the ICU, a second-look surgery was performed for definitive reconstruction: Roux-en-Y gastroenteroanastomosis, duct-to-mucosa pancreaticojejunostomy, and bilienteric anastomosis. During the postoperative period, transverse colostomy dehiscence and a biliopancreatic mucous fistula occurred, which were managed with a definitive laparotomy, local drainage, and prolonged vacuum-assisted closure. The patient was discharged after 87 days, without a stoma, ambulating, and on oral intake. Approximately 14 months after the initial trauma, the patient underwent intestinal reconstruction and incisional hernioplasty, with no further complications following the procedure.

Discussion: High-grade pancreaticoduodenal traumas (AAST 4–5) present an in-hospital mortality rate exceeding 12%, primarily due to hemorrhage and injury to adjacent organs. The protocol for unstable patients indicates immediate laparotomy. For AAST 3–4 injuries, primary repair or external drainage associated with damage control is usually sufficient; however, AAST 5 injuries (involving the pancreatic duct or Ampulla of Vater) indicate resection. Pancreaticoduodenectomy in trauma, although controversial, is indicated in < 1% of cases when primary repair of the pancreatic and duodenal ducts is impossible. Studies report mortality rates of up to 34% in this context,...

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ARCHIVAL RECORD

Whipple Procedure in Trauma: A Case Report of Complex Gunshot Injury

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Keywords: Trauma, Wounds, Laparotomy, Multiple Trauma

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1. Introduction

Interpersonal violence and public insecurity remain major challenges for both the Brazilian population and governmental authorities. In Brazil, violence is the leading cause of healthy years of life lost. Among the causes of lethal violence, firearm-related injuries stand out, accounting for more than 70% of all homicides in the country. Although the number of firearm-related deaths and hospital admissions has declined over the past decade, more than 35,000 firearm-related deaths continue to occur annually, according to data from the Instituto Sou da Paz. In 2021, among the 35,217 firearm-related deaths recorded nationwide, only 7,893

occurred within hospitals or other healthcare facilities, reflecting the extremely high lethality of this mechanism of injury (1).

Patients who survive the initial injury and reach healthcare services often require highly complex treatment, resulting in substantial costs to the Brazilian Unified Health System (SUS) and hospital services. Firearm injuries (FIs) account for approximately one-quarter of all deaths from external causes but only 1.4% of hospital admissions related to external causes. Nevertheless, these injuries generated healthcare expenditures of approximately BRL 41 million for the SUS in 2022. The average hospitalization cost for firearm-injured patients is 59% higher than that associated with other forms of assault (1).

Given its relevance within the national context, surgeons must be familiar with the diagnosis and management of the diverse injuries resulting from firearm trauma. Despite the high incidence of penetrating trauma caused by firearms, pancreatic and duodenal injuries remain uncommon. Among severe traumatic injuries, duodenal involvement occurs in approximately 0.2–0.6% of cases and represents only 3–5% of abdominal trauma cases (2). Pancreatic injuries are similarly rare, occurring in approximately 0.2% of blunt trauma cases and 1.1% of penetrating trauma cases, accounting for less than 12% of all abdominal injuries (3,4).

In a study conducted by O'Reilly et al., more than 350,000 trauma cases admitted to hospitals in England, Wales, and Northern Ireland between 1989 and 2013 were analyzed to assess the epidemiology of pancreaticoduodenal trauma. Despite important epidemiological differences compared with Brazil, only 0.32% of all trauma cases involved pancreaticoduodenal injuries, corresponding to 4.7% of all abdominal trauma cases identified in the study (5).

Due to the rarity of these injuries, the optimal surgical management remains controversial. Clinical outcomes depend largely on the severity of organ damage and the patient's hemodynamic status, factors that directly influence mortality, morbidity, and treatment strategy (2,4,6). While less severe injuries may be managed conservatively or with simple primary repair, more extensive injuries often require aggressive surgical intervention and/or a damage control approach (2,4,7).

Considering the rarity of these lesions and the challenges associated with defining the optimal treatment strategy, we report a case of a firearm injury involving multiple abdominal organs, with particular emphasis on pancreatic and duodenal trauma. As part of a damage control strategy, a pancreatoduodenectomy with gastric resection was performed, followed by delayed reconstruction in a second-stage procedure.

2. Case presentation

A previously healthy 23-year-old male was admitted to the emergency department after sustaining a firearm injury. The interval between injury and hospital admission was approximately one hour. During prehospital care, the trauma team administered 1 g of tranexamic acid and 500 mL of normal saline.

Upon arrival, the patient presented with a Glasgow Coma Scale (GCS) score of 5 (eye opening: 2, verbal response: 2, motor response: 1), and immediate endotracheal intubation was performed to secure the airway. Physical examination revealed a gunshot entry wound at the left midclavicular thoracoabdominal junction, associated with omental evisceration, without an identifiable exit wound. Palpation detected the projectile lodged in the posterior aspect of the right hemithorax, along the posterior axillary line at the level of the tenth rib. The abdominal examination was also suggestive of generalized peritonitis. Given the patient's hemodynamic instability and visceral evisceration, he was immediately transferred to the operating room.

A midline exploratory laparotomy was performed. Intraoperative findings included a transverse colon injury involving more than 50% of the circumference without complete transection (AAST grade III), a through-and-through gastric injury (AAST grade III), a penetrating injury to the second portion of the duodenum (AAST grade III), and a severe pancreatic head injury associated with disruption of the distal common bile duct (AAST grade V).

Considering the extent of the injuries and the patient's critical hemodynamic condition, a damage control strategy was adopted. A primary repair of the transverse colon was performed, followed by partial gastrectomy using a linear stapler. The third portion of the duodenum was mobilized and transected using a linear stapler. The pancreatic head was resected with a linear stapler, while the remaining pancreatic structures were left in situ because of the patient's profound hemodynamic instability. At the conclusion of the procedure, the patient required high doses of vasopressor support. Temporary abdominal closure with negative-pressure therapy was performed, and a fine nasogastric tube was positioned through the common bile duct for external biliary drainage into an ostomy collection bag. Massive transfusion was required intraoperatively, including four units of cryoprecipitate, two units of fresh frozen plasma, and two units of packed red blood cells.

After 48 hours of intensive care unit (ICU) resuscitation and stabilization, vasopressor requirements had significantly decreased, allowing definitive reconstruction. Re-exploration was performed with restoration of gastrointestinal and biliary continuity. Reconstruction included a gastrojejunostomy, a pancreaticojejunostomy with placement of a urethral catheter as an internal pancreatic duct stent, duct-to-mucosa anastomosis, and pancreatic invagination (telescoping) technique. Biliary continuity was restored through a Roux-en-Y hepaticojejunostomy.

During the following month, the patient developed dehiscence of the transverse colonic repair and obstruction of the biliopancreatic limb. Consequently, a transverse colostomy and a mucous fistula of the biliopancreatic limb were created. Following the procedure, the patient remained with an open abdomen managed by negative-pressure therapy, with dressing changes every 48 hours.

After multiple surgical interventions, two attempts at definitive abdominal closure were unsuccessful: one due to leakage from an enteroatmospheric fistula and the other because of the inability to mobilize the retracted skin in a hostile frozen abdomen. Following multidisciplinary discussion with the wound and ostomy care team, a specialized home-based dressing protocol was established, which was feasible due to the family's ability to provide adequate care with support from a private healthcare service.

The patient was discharged after 87 days of hospitalization. At discharge, he tolerated a full oral diet, had a well-functioning stoma, and was independently ambulatory. Tracheostomy decannulation was successfully performed under bronchoscopic guidance before discharge. Outpatient follow-up was scheduled for continued monitoring and management of potential late complications.

During follow-up, the patient demonstrated an excellent recovery, rapidly adapting to his new routine and experiencing no additional complications. Approximately six months after discharge, preoperative preparation for restoration of intestinal continuity and repair of the large incisional hernia was initiated. Definitive reconstruction was performed 14 months after the initial operation. The stoma and mucous fistula were resected and stapled, followed by a hand-sewn side-to-side colocolonic anastomosis. Complete abdominal wall closure was achieved, and a large polypropylene mesh was implanted. The patient was discharged during the same week. At the outpatient visit seven days later, he was asymptomatic and recovering well. Subsequently, he was lost to follow-up.

3. Discussion

Pancreaticoduodenal trauma is uncommon but associated with substantial morbidity and mortality, with reported in-hospital mortality rates approaching 12% (2). Early mortality is primarily related to uncontrolled hemorrhage and associated vascular or visceral injuries, whereas late mortality is more frequently attributable to infectious complications and multiple organ failure (6).

The initial management of these patients is dictated by their physiological status. Trauma assessment should follow Advanced Trauma Life Support (ATLS) principles, with subsequent management guided by hemodynamic stability and the presence of peritoneal signs. In hemodynamically stable patients without indications for immediate laparotomy, contrast-enhanced computed tomography is the diagnostic modality of choice, demonstrating a sensitivity of 86% and specificity of 88% for duodenal injuries (2).

Most pancreatic and duodenal injuries are low-grade lesions. High-grade injuries, such as those described in the present case, are considerably less frequent and usually require aggressive surgical management (5,6). Low-grade pancreatic injuries (AAST grades I–II) may be managed nonoperatively in selected patients, whereas grades III and IV frequently require resection when technically feasible. Due to their rarity and high associated mortality, grade V pancreatic injuries remain poorly represented in the literature, and their optimal management remains controversial (4).

Similarly, contemporary management of duodenal trauma favors a “less-is-more” philosophy, emphasizing the simplest effective repair whenever possible. While low-grade injuries can often be managed conservatively or with primary repair, more extensive injuries may necessitate complex reconstruction. In cases of severe tissue destruction, technical difficulty, or profound physiological derangement, damage-control surgery followed by delayed definitive repair after 24–48 hours of intensive care resuscitation is generally recommended (2).

In the present case, extensive destruction of the pancreatic head associated with distal bile duct disruption and severe duodenal injury precluded organ-preserving strategies. Ongoing hemorrhage and extensive tissue devitalization prompted the decision to perform a pancreaticoduodenectomy. Accepted indications for trauma-related pancreaticoduodenectomy include massive pancreatic head injury involving the main pancreatic duct, irreparable distal bile duct disruption, ampullary avulsion, and devastating combined pancreaticoduodenal injuries (2,6).

Although pancreaticoduodenectomy is a well-established procedure in hepatopancreatobiliary oncology, its role in trauma remains controversial because of the considerable physiological burden imposed on critically injured patients. Morbidity and mortality are strongly influenced by the patient's physiological reserve, associated injuries, and timing of intervention (3). In a review by Krige et al., encompassing 220 trauma-related pancreaticoduodenectomies, the overall mortality rate reached 34%, highlighting the severity of these injuries and the complexity of their management (6).

Current evidence supports a staged approach in unstable patients. Damage-control surgery allows rapid control of hemorrhage and contamination while avoiding prolonged operative times during periods of physiological exhaustion. Definitive reconstruction can then be performed after adequate resuscitation in the intensive care unit. In the present case, restoration of gastrointestinal, biliary, and pancreatic continuity was successfully achieved during a planned second-look operation. While some authors advocate

temporary management of the pancreatic remnant with delayed reconstruction by specialized hepatopancreatobiliary teams, the availability of a liver transplantation and hepatobiliary surgery team at our institution allowed complete reconstruction during the second-stage procedure (2).

Postoperative management is equally critical and requires a multidisciplinary approach. Open abdomen management is frequently employed following damage-control surgery to prevent abdominal compartment syndrome and facilitate planned re-exploration. Current recommendations advocate reoperation within 24–48 hours whenever possible, with definitive closure pursued as soon as physiological and technical conditions permit. Temporary abdominal closure using negative-pressure therapy has become the preferred strategy because of its effectiveness in controlling contamination and facilitating abdominal domain preservation (8).

Despite these advantages, prolonged open abdomen management is associated with significant complications, including severe nutritional deficits, enteroatmospheric fistula formation, frozen abdomen, and loss of abdominal wall domain. Several of these complications were observed in the present case, ultimately requiring prolonged hospitalization and delayed abdominal wall reconstruction (8).

Anastomotic dehiscence and fistula formation remain among the most feared complications following pancreaticoduodenectomy in the trauma setting. Given that approximately 5 liters of gastric, biliary, pancreatic, and salivary secretions pass through the duodenum daily, leakage from the reconstruction can result in severe local and systemic consequences. In most cases, management is based on adequate external drainage, source control, nutritional support, and negative-pressure wound therapy. In selected retroperitoneal leaks, additional drainage procedures, including flank approaches and controlled external diversion techniques, may be necessary to achieve adequate source control (2).

Despite a prolonged and highly complex postoperative course, the patient ultimately achieved full oral intake, independent ambulation, successful restoration of intestinal continuity, and definitive abdominal wall reconstruction. This favorable outcome highlights the importance of multidisciplinary management, staged surgical strategies, and access to specialized hepatopancreatobiliary expertise in the treatment of catastrophic pancreaticoduodenal trauma.

4. Conclusion

The management of complex pancreaticoduodenal trauma requires rapid decision-making, familiarity with damage-control principles, and coordinated multidisciplinary critical care. In such scenarios, surgical decisions influence not only patient survival but also long-term morbidity and functional recovery.

The present case illustrates the successful management of a catastrophic penetrating pancreaticoduodenal injury through a staged damage-control approach followed by delayed definitive reconstruction. Despite a prolonged postoperative course and multiple complications, favorable functional recovery was achieved in a specialized trauma center with access to hepatopancreatobiliary expertise, advanced critical care resources, and comprehensive multidisciplinary support.

Although pancreaticoduodenectomy is traditionally associated with oncologic surgery, it remains a valuable therapeutic option in carefully selected patients with devastating pancreatic head, distal bile duct, and duodenal injuries. When combined with physiologic-

ical resuscitation and delayed reconstruction, this strategy may provide a lifesaving alternative in otherwise unsurvivable injuries.

Given the rarity of high-grade pancreaticoduodenal trauma and the limited evidence available, further multicenter studies are required to better define treatment algorithms and establish consensus regarding the optimal management of these challenging injuries.

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PEER REVIEW

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Abstract

Introduction: Firearm violence accounts for more than 70% of homicides in Brazil and represents a significant cause of years of potential life lost. Gunshot wounds to pancreaticoduodenal organs are rare (representing only 0.3% of abdominal traumas) and carry high morbidity and mortality rates. The literature recommends conservative treatment or primary repair for AAST grade 1–2 injuries, while more severe injuries (AAST 3–5) may require damage control strategies and, in selected cases, extensive resections such as pancreaticoduodenectomy (Whipple procedure).

Case Report: A 23-year-old male, victim of a thoracoabdominal gunshot wound, arrived at the emergency department with a Glasgow score of 5 and hemodynamic instability. He was intubated and underwent an emergency midline laparotomy.

The identified injuries were: 1. Transverse colon > 50% of the circumference (AAST grade 3); 2. Transfixing stomach injury (AAST grade 3); 3. Duodenum, D2 portion (AAST grade 3); 4. Head of the pancreas with distal bile duct rupture (AAST grade 5).

A damage control approach was chosen: primary suture of the colon, partial gastrectomy, and resection of the duodenum and pancreatic head, followed by vacuum-assisted closure (peritoneostomy). After 48 hours in the ICU, a second-look surgery was performed for definitive reconstruction: Roux-en-Y gastroenteroanastomosis, duct-to-mucosa pancreaticojejunostomy, and bilioenteric anastomosis. During the postoperative period, transverse colostomy dehiscence and a biliopancreatic mucous fistula occurred, which were managed with a definitive colostomy, local drainage, and prolonged vacuum-assisted closure. The patient was discharged after 87 days, without a stoma, ambulating, and on oral intake. Approximately 14 months after the initial trauma, the patient underwent intestinal reconstruction and incisional hernioplasty, with no further complications following the procedure.

Discussion: High-grade pancreaticoduodenal traumas (AAST 4–5) present an in-hospital mortality rate exceeding 12%, primarily due to hemorrhage and injury to adjacent organs. The protocol for unstable patients indicates immediate laparotomy. For AAST 3–4 injuries, primary repair or external drainage associated with damage control is usually sufficient; however, AAST 5 injuries (involving the pancreatic duct or Ampulla of Vater) indicate resection. Pancreaticoduodenectomy in trauma, although controversial, is indicated in < 1% of cases when primary repair of the pancreatic and duodenal ducts is impossible. Studies report mortality rates of up to 34% in this context,...

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FULL ABSTRACT

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Firearm violence accounts for more than 70% of homicides in Brazil and represents a significant cause of years of potential life lost. Gunshot wounds to pancreaticoduodenal organs are rare (representing only 0.3% of abdominal traumas) and carry high morbidity and mortality rates. The literature recommends conservative treatment or primary repair for AAST grade 1–2 injuries, while more severe injuries (AAST 3–5) may require damage control strategies and, in selected cases, extensive resections such as pancreaticoduodenectomy (Whipple procedure).

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ARCHIVAL RECORD

Cirurgia de Whipple no Trauma: Relato de Caso de Lesão Complexa Por Arma de Fogo

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Abstract

Introdução: A violência por arma de fogo é responsável por mais de 70 % dos homicídios no Brasil e representa importante causa de anos de vida saudável perdidos. Ferimentos por arma de fogo em órgãos pancreatoduodenais são raros (apenas 0,3 % dos traumas abdominais) e representam alta morbimortalidade. A literatura recomenda tratamento conservador ou reparo primário para lesões AAST grau 1-2, enquanto lesões mais graves (AAST 3-5) podem exigir estratégias de "damage control" e, em casos selecionados, ressecções extensas como a gastroduodenopancreatectomia (Whipple).

Caso: Paciente masculino, 23 anos, vítima de ferimento por arma de fogo toracoabdominal, chegou ao pronto-socorro em Glasgow 5 e instabilidade hemodinâmica. Foi intubado e submetido à laparotomia mediana de urgência. As lesões identificadas foram: 1. Cólon transverso > 50 % da circunferência (AAST grau 3); 2. Estômago transfixante (AAST grau 3); 3. Duodeno, porção D2 (AAST grau 3); 4. Cabeça do pâncreas com ruptura do ducto biliar distal (AAST grau 5).

Optou-se por abordagem de damage control: sutura simples do cólon, gastrectomia parcial e ressecção do duodeno e cabeça pancreática, seguido de peritoniotomia a vácuo. Após 48 horas em UTI, realizou-se reoperação para reconstrução definitiva: gastroenteroanastomose em Y de Roux, pancreatojejunal ducto-mucosa e anastomose biliodigestiva. No período pós-operatório, ocorreram deiscência de colostomia transversa e fístula mucosa biliopancreática, manejadas com colostomia definitiva, drenagem local e peritoniotomia a vácuo prolongada. Paciente teve alta em 87 dias, já sem estoma, deambulando e com alimentação via oral. Cerca de 14 meses após o trauma inicial, o paciente passou por uma reconstrução intestinal e hernioplastia incisional, sem novas complicações após o procedimento. **Discussão:** Traumas pancreatoduodenais de alto grau (AAST 4-5) apresentam mortalidade intra-hospitalar superior a 12 %, especialmente por sangramentos e injúria de órgãos adjacentes. O protocolo em paciente instável indica imediata laparotomia. Para lesões AAST 3-4, o reparo primário ou drenagem externa associada a controle de danos costuma bastar; já as lesões AAST 5 (envolvendo ducto pancreático ou ampola de Vater) indicam ressecção. A gastroduodenopancreatectomia no trauma, embora controversa, é indicada em < 1 % dos casos quando há impossibilidade de reparo primário do ducto pancreático e duodenal. Estudos apontam mortalidade de até 34 % nesse contexto, ressaltando a importância de realizar a reconstrução em segundo tempo, após estabilização hemodinâmica, e curativo com pressão negativa para reduzir síndrome compartimental. A nutrição enteral precoce e o manejo multidisciplinar são cruciais para minimizar complicações tardias, como fístulas e deiscências.

Keywords: Trauma, Surgical Wound Dehiscence, Gunshot, Pancreas, Pancreatectomy

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1. Introdução

No cenário nacional, a violência interpessoal e a falta de segurança pública, ainda é um grande problema a ser enfrentado pela população e pelas esferas governamentais responsáveis. No Brasil, a violência aparece como a principal causa de anos de vida saudável perdidos da população. Dentre as causas de violência letal, destaca-se o uso da arma de fogo, que representa mais de 70% dos homicídios praticados no país. Além disso, destaca-se que, apesar da queda no número de óbitos e atendimentos hospitalares na última década, ainda há mais de 35 mil óbitos por arma de fogo por ano em todos os anos estudados no levantamento realizado pelo Instituto Sou da Paz. No ano de 2021, dos 35 217 óbitos por arma de fogo, apenas 7 893 foram registrados dentro de hospitais e outros estabelecimentos

de saúde, o que reflete a massiva letalidade dessa forma de agressão (1)

Aqueles que sobrevivem ao primeiro agravo e chegam aos serviços de saúde, devido à alta complexidade dos tratamentos, demandam altos custos ao SUS e, sobretudo, aos serviços hospitalares. Os ferimentos por arma de fogo (FAF), respondem por ¼ dos óbitos por causas externas, mas apenas 1,4% das internações por causas externas e, ainda assim, custaram em 2022 R\$ 41 milhões ao SUS. O valor médio da internação desses pacientes custa 59% a mais do que as internações das outras formas de agressão (1).

Visto a importância dentro da realidade nacional, o cirurgião deve entender e manejar as diferentes lesões decorrentes de FAFs. Apesar da grande incidência desse subtipo de trauma penetrante, são raros os

casos com acometimento de pâncreas e duodeno. Dentre os traumas graves, cerca de 0,2 – 0,6% acometem duodeno, sendo baixa também a incidência dentre os traumas abdominais, 3 – 5% (2). Quanto a lesão de pâncreas, a baixa incidência indica também raridade desses casos, cerca de 0,2% no trauma contuso e 1,1% nos traumas penetrantes, representando menos de 12% dos traumas abdominais (3), (4). Em estudo realizado por O'Reilly et al, foram analisados mais de 350 000 casos em hospitais da Inglaterra, País de Gales e Irlanda do Norte entre 1989 e 2013, de forma a analisar dados epidemiológicos acerca do trauma em pâncreas e duodeno. Nesta publicação, apesar das diferenças epidemiológicas em comparação com o Brasil, apenas 0,32% de todos os traumas tiveram acometimento pancreatoduodenal, o que representa 4,7% de todos os traumas abdominais levantados (5).

Como esse tipo de lesão é muito esporádica, o tratamento cirúrgico de escolha ainda é controverso. A gravidade do caso depende do grau de acometimento do órgão e estabilidade clínica do paciente, o que determina não apenas mortalidade e morbidade, mas também o melhor tratamento a ser empregado (2,4,6). Enquanto lesões mais leves podem ser manejadas de maneira conservadora ou com correção primária simples, lesões mais graves necessitam tratamento mais agressivo e/ou estratégia de “*damage control*” (2,4,7)

Visto a raridade das lesões e a dificuldade em definir tratamento, este estudo visa relatar um caso de FAF com acometimento de múltiplos órgãos, com maior enfoque nas lesões pancreática e duodenal, no qual, em estratégia de *damage control*, foi optado por realizar uma ressecção gastropancreatoduodenal e reconstrução em segundo tempo.

2. Apresentação do caso

Paciente WOS, 23 anos, previamente hígido, chega ao serviço de emergência após FAF, decorridos 1 hora do trauma até a admissão hospitalar. Trazido por equipe de atendimento ao trauma, foi realizado em regime pré-hospitalar 1g de Ácido Tranexâmico e 500ml de soro fisiológico. Na chegada, paciente em escala de coma de Glasgow de 5 (2 pontos em abertura ocular; 2 pontos na resposta verbal; 1 ponto na resposta motora), portanto optado por via aérea artificial com intubação orotraqueal (IOT) de imediato. Durante exame, visualizado FAF com orifício de entrada em linha hemiclavicular da transição toracoabdominal a esquerda com evisceração de omento, sem orifício de saída. Durante a palpação, percebeu-se o projétil alojado em dorso de hemitórax direito, em linha axilar posterior na altura do 10º arco costal, além de sinais sugestivos de peritonite no exame abdominal. Devido à instabilidade do paciente e evisceração, foi encaminhado imediatamente ao centro cirúrgico.

Em abordagem cirúrgica, realizado acesso por laparotomia mediana. Durante inventário da cavidade, encontrou-se lesão de cólon transversal >50% da circunferência, sem transecção (grau 3 pela American Association for the Surgery of Trauma [AAST]), somado a lesão transfixante de estômago (grau 3 AAST), duodeno em sua segunda porção (grau 3 AAST) e cabeça do pâncreas, com ruptura do ducto biliar distal (grau 5 AAST). Decorrente à grande morbidade da lesão e crítica condição hemodinâmica no momento, foi optado por cirurgia de “*damage control*”, realizando sutura simples de cólon transversal, associado a gastrectomia parcial com grampeador linear, liberado e seccionado duodeno em sua terceira porção com grampeador linear, secção de cabeça do pâncreas com grampeador linear e mantido demais porções pancreáticas por decorrência da instabilidade hemodinâmica neste momento. Paciente ao fim do procedimento necessitava de altas doses de drogas vasoativas (DVA), foi mantido em peritoniotomia a vácuo e com sonda nasogástrica

final comunicando colédoco com o externo, alocada em bolsa de colostomia. No intraoperatório, foi necessário hemotransfusão, totalizando 4 crioprecipitados, 2 plasmas e 2 concentrados de hemácias.

Após 48h de manejo clínico em unidade de tratamento intensivo (UTI), paciente apresenta redução da demanda de DVA e com isso, foi optado por reabordar com objetivo de reconstruir trânsito alimentar e biliar. Realizada nova laparotomia com reconstrução de trânsito intestinal em gastroenteroanastomose, com anastomose pancreatojejunal e inserção de sonda uretral em ducto pancreático, realizada anastomose ducto mucosa e técnica de telescopagem pancreática. Reconstrução de via biliar por anastomose biliodigestiva em Y de Roux.

No mês subsequente, sob manejo clínico, paciente desenvolveu deiscência de colorrafia de cólon transversal e bloqueio em alça biliopancreática. Assim, foi confeccionada colostomia de transversal e fístula mucosa da alça biliopancreática. Ao fim do procedimento, mantido paciente em peritoniotomia a vácuo com trocas a cada 2 dias.

Após sucessivas abordagens cirúrgicas, paciente permaneceu em peritoniotomia com 2 tentativas de fechamento, uma falhou por extravasamento de conteúdo em FO e outra por impossibilidade de mobilizar pele retraída em um abdome congelado. Discutido, portanto, com equipe de estomatoterapia que orienta realizar curativo especial em casa, família com condições para acompanhar em conjunto com clínica privada.

Paciente recebeu alta após 87 dias de internamento, aceitando dieta integralmente por via oral, com estoma adaptado e funcionante, além do paciente deambulando sem auxílio. Antes da alta foi realizada decanulação de traqueostomia via broncoscopia. Definido planejamento de acompanhamento ambulatorial do seguimento domiciliar e complicações tardias.

Em ambulatório, paciente apresentou recuperação excelente, com rápida adaptação a nova rotina e sem novas complicações. Cerca de 6 meses após a alta hospitalar, iniciou-se o processo de preparo pré-operatório para reconstrução de trânsito e correção da extensa hernia incisional. O procedimento foi então realizado 14 meses após a primeira abordagem cirúrgica. Foi realizada a retirada do estoma e fístula mucosa, realizado grampeamento destas, seguido de anastomose colo-colônica laterolateral manual. Foi possível o fechamento da parede abdominal e aplicação de tela de polipropileno extensa. O paciente foi dispensado do internamento na mesma semana. No retorno ambulatorial 7 dias após a alta, o paciente estava bem e sem queixas, após essa consulta, o paciente perdeu seguimento.

3. Discussão

Os traumas pancreatoduodenais são pouco comuns, mas de relevante mortalidade, com cerca de 12% no intra-hospitalar (2). A mortalidade precoce é mais relacionada a sangramento venoso incontrolável ou lesão de órgãos adjacentes, enquanto a mortalidade tardia tem maior relação com infecção ou falência de órgãos (6).

A abordagem inicial depende do estado geral do paciente. Primeiramente deve-se realizar o atendimento ao trauma seguindo os princípios do ATLS. Após o manejo imediato, a decisão de realizar exame de imagem ou encaminhar diretamente a sala de cirurgia é ancorada quanto a estabilidade hemodinâmica e sinais de peritonite. Caso paciente apresente estabilidade e sem sinais claros de abdome cirúrgico, o exame de escolha é a tomografia. A tomografia contrastada tem uma sensibilidade de 86% e especificidade de 88% na detecção de lesões duodenais (2).

A grande maioria dos traumas em pâncreas e duodeno são de menor gravidade (AAST 1), os casos mais graves, como mostrado neste relato de caso, são menos comuns e demandam tratamento agressivo (5,6). Nas lesões pancreáticas AAST 1 ou 2, podem ser considerados para manejo conservador, enquanto nas lesões 3 ou 4 recomenda-se a ressecção quando possível. O manejo dos traumas grau 5, devido à alta mortalidade, têm menos dados em literatura e um tratamento mais controverso (4). As lesões duodenais devem ter uma abordagem de “menos é mais”, ou seja, optar pela abordagem mais simples em um primeiro momento. As lesões classificadas como AAST grau 1 devem ser manejadas de maneira clínica, com uso de sonda nasoenteral (SNE) para repouso duodenal. A partir do grau 2, preconiza-se o tratamento cirúrgico, sempre que possível com reparo direto e, se viável, anastomose no primeiro tempo. Quando há dificuldade técnica na primeira abordagem ou lesões AAST grau 4 ou 5, o ideal é a estratégia de controle de danos com reparo definitivo em 24 a 48h, após estabilidade clínica em UTI (2).

No caso descrito neste trabalho, evidenciaram-se lesões graves em duodeno e, sobretudo, pâncreas nas quais, devido ao sangramento e desvitalização de tecidos, foi optado por realizar a gastroduodenopancreatotomia. As indicações para tal procedimento no trauma são: lesão massiva em cabeça de pâncreas, com envolvimento do ducto pancreático, sem possibilidade de reparo; ruptura do ducto biliar distal no pâncreas, com lesão AAST grau 5 de duodeno; lesão que avulsione a ampola de Vater no duodeno (2,6). Considerando essas indicações, o procedimento é bem indicado, apesar de opiniões que indiquem contra o procedimento de *Whipple* no trauma, por conta da grande mortalidade do procedimento neste contexto (6). As taxas de morbimortalidade variam de acordo com o estado geral do paciente, a gravidade das lesões e o tempo até a abordagem (3). Uma análise por Krige et al, no entanto, levantou 220 pancreatoduodenectomias no trauma e encontrou uma mortalidade de 34% (6). A reconstrução, sobretudo em casos de maior instabilidade hemodinâmica, deve preferencialmente ser realizada em uma segunda abordagem (2,6). A reconstrução preconizada pela literatura se resume em uma anastomose colédoco-jejunal e uma gastro – jejuno anastomose, em Y de Roux, associada a colecistectomia. O pâncreas deve preferencialmente ser mantido in situ e realizada sutura com fio não absorvível, para considerar reconstrução pancreato-enterica com uma equipe hepatobiliar ou de transplante (2). Como em nosso serviço, dispomos de equipe com ampla experiência em transplante hepático, foi optado pela reconstrução de todas as ressecções já na segunda abordagem.

O manejo clínico pós cirúrgicos é de crucial importância e deve ser realizado preferencialmente por equipe multidisciplinar. A opção pelo abdome aberto no trauma é indicada naqueles pacientes que passam por cirurgia de “*damage control*”, devido ao alto risco de síndrome compartimental abdominal se realizado o fechamento da parede abdominal, além de facilitar o procedimento de reoperação. A reoperação deve acontecer idealmente dentro de 24 a 48h no máximo, com fechamento definitivo assim que condições clínicas e cirúrgicas viáveis. A técnica de preferência é a peritoniotomia com pressão negativa, ou curativo de Barker. Nestes casos com abdome aberto em pressão negativa, o manejo multidisciplinar se mostra essencial, pois estes pacientes têm um déficit nutricional crítico, o que pode retardar o processo de recuperação pós-operatório. A longo prazo, as principais complicações relacionadas ao método são a formação de fistulas enteroatmosféricas e, como no caso apresentado, o desenvolvimento de abdome em bloco e retração da parede abdominal, o que interfere no fechamento definitivo (8).

A grande complicação desse procedimento no cenário do trauma são as deiscências de anastomose e, conseqüentemente, fistulas. Pelo pertuito do duodeno, circula cerca de 5L de fluidos por dia,

desde gástricos, bile, suco pancreático e saliva. Esses vazamentos são em geral tratados de maneira conservadora por meio de drenagem externa e curativos com pressão negativa (a exemplo da peritoniotomia com pressão negativa). Uma opção viável, sobretudo em órgãos retroperitoneais é a realização de lombotomia com empacotamento e alocação bolsa de colostomia para drenagem externa ou curativo com pressão negativa no local da incisão posterior (2).

4. Conclusão

Diante de lesões complexas, sobretudo no cenário do trauma, o cirurgião se depara com a necessidade de tomar decisões rápidas e assertivas que podem definir não apenas a sobrevivência do paciente, mas também a morbidade após a alta hospitalar. Para tanto, se faz necessário o conhecimento do arsenal terapêutico, das estratégias de *damage control* e do manejo multidisciplinar em UTI. O caso apresentado ilustra uma situação catastrófica que foi bem manejada em primeira abordagem e, como inserido em um centro de trauma com boa infraestrutura e profissionais especializados, teve uma evolução satisfatória, com alta hospitalar dentro de 90 dias. O procedimento de *Whipple* que é tradicionalmente empregado no cenário oncológico, pode ser também transposto nos ferimentos penetrantes. Permanece a necessidade de mais trabalhos, em diferentes centros de trauma, e que discutam as melhores alternativas no trauma pancreatoduodenal grave, pois por mais que exista uma gama de opções para abordar tais lesões, não há um consenso ou uma sistematização bem definida do fluxo terapêutico ideal a ser seguido.

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Subject Index

Technical concepts and key subjects are indexed at their verified discussion pages.

KEY SUBJECTS Scalar Wave • Trauma • Zygomaticomaxillary Complex Fracture • Ferimentos Por Arma de Fogo • Open Reduction and Internal Fixation • Torsion Field • Wounds • Gravitational Field

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We believe that the purpose of a medical journal is to amplify the voice of the clinician-researcher. Every operational decision we make is guided by a single principle: *the author should never be distracted from the science of healing*. Our professional editorial and production teams exist to handle every technical and logistical complexity so that you can devote your full energy to your medical research.

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