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SUICIDE OR HOMICIDE: CONTROVERSIES BETWEEN INVESTIGATION DATA AND AUTOPSY CONCLUSIONS

Carmen Corina Radu[1], Paula Roxana Adi[2,*], Vlad Cristian Răuță[2], Dacian Ioan Biriș[2], Laura Chinezu[2], Carmen Ioana Biriș[1]

[1]*"George Emil Palade" University of Medicine, Pharmacy, Sciences and Technology,* [2]*Institute of Legal Medicine, Targu Mures, Romania*

Abstract: Suicide by intraoral explosion of pyrotechnic materials is rarely described in the international literature, occupying the lowest position in terms of fatalities from explosions following terrorist attacks and accidental deaths. The approach in these cases should primarily exclude other causes of death, whose tanatogenic injuries may be masked by blast trauma. We present the case of a man found dead with severe open craniofacial trauma and multiple viscero-cranial fractures. On-site investigation reveals no signs of forced entry, a handwritten note, the presence of a firecracker in the nightstand drawer, dust on the wall and cardboard fragments beneath blankets, as well as the presence of bloodstains. Considering the asymmetric distribution, the vital/non-vital nature of the injuries, and the regular/irregular shape, along with the histopathological absence of burn injuries and the negative response to diphenylamine reaction, the necropsy findings cannot exclude the possibility of homicide by repeated direct blows with a hard-splitting object. The on-site investigation portrays the scene of a suicide through an explosion mechanism using a pyrotechnic device applied in the oral cavity, with discrepancies between the position of the corpse, bloodstains, and wall marks resulting from firecracker explosion. Detailed autopsy examination and the use of complementary histopathological and forensic examinations in such atypical cases are not sufficient to determine the manner of death. It is crucial to conduct a comprehensive and meticulous on-site investigation, necessarily involving the participation of a forensic pathologist, and to correlate the investigation data with the findings of the autopsy report.

Keywords: on-site investigation, suicide, homicide, dissimulation, explosion, firecracker.

INTRODUCTION

Suicide by intraoral explosion of pyrotechnic materials is rarely described in the international literature, ranking lowest in terms of explosion-related deaths compared to terrorist attacks and accidental fatalities. The approach to such cases must first exclude other causes of death whose tanatogenic injuries may be masked by the trauma caused by the explosion. In addition to the role of forensic physicians, on-site investigation significantly contributes to establishing the factual situation, which is an important scientific method involving the direct investigation of a location or event to collect relevant data, samples, and information. The correlation of medico-legal conclusions with on-site research findings ensures the accuracy of the facts, provided each has been meticulously documented and argued. This paper aims to address the controversies between the investigation data and autopsy observations in a complex case of death resulting from the placement and intraoral activation of a sound-emitting pyrotechnic device. To provide relevant data for a more accurate interpretation of the case, we even conducted a complex experimental study, the results of which proved to be useful. Finally, after a section of constructive and educational discussions, the paper is structured around two hypotheses, one of homicide, and the other of suicide, without ignoring the investigative shortcomings.

CASE DESCRIPTION

A dead 56-year-old male is brought to the Institute of Forensic Medicine in Targu Mures for an

*Correspondence to: Adi Paula Roxana, Institute of Legal Medicine, 38 Gheorghe Marinescu street, Targu Mures, Mures County, Romania, E-mail: paula.adi@rivulusad.ro

autopsy. The information known at that time was provided by the police, stating that the victim had characteristic injuries resulting from animal bites.

During the external examination of the cadaver, bloodstains are observed on the hands bilaterally, on the anterior thoraco-abdominal region, and on the clothing. There is also evidence of putrefaction in the lower abdomen and the following traumatic injuries: split-lacerated wounds at the facial level with multiple flaps confluent with each other, hard palate wounds, a multi-fracture of the viscerocranium (nasal pyramid, maxilla, left zygomatic arch, mandible), cut wounds on the tongue, a right submental wound, linear cranial fracture in the anterior cranial floor, ethmoidal blade fracture, and left periorbital ecchymosis with subconjunctival hemorrhage.

The internal examination of the cadaver reveals the absence of blackish soot or residue in the oropharynx and upper respiratory tract, the absence of cardboard fragments, the absence of lips, a partial section of the right common carotid artery on the anterior surface, as a 0.5 cm long incised wound, obliquely descending toward the right shoulder, a glottic orifice with traces of glossy blackish blood in small quantities, cerebral edema, anemic internal organs with incipient autolysis, pulmonary edema and emphysema, with no other significant pathological findings.

Complementary examinations included toxicological, histopathological, serological, and bio-criminalistic analyses. The decedent's blood alcohol content was 0.14 g per 1000 ml. In addition to the analysis of core fragments, including the brain, heart, lungs, kidneys, and liver, the histopathological report based on the examination of three skin fragments and one from the tongue yielded the following interpretation: the histopathological appearance of the examined fragments is polymorphic, with areas of discontinuity/ulceration, some associated with hematic infiltrates and areas of necrosis in the surrounding tissues. This heterogeneous and multifocal appearance, with vital lesions alternating with post-mortem ones, should be interpreted in consideration of the investigative data, as well as the presence of autolysis, and the overall histopathological appearance may favor injuries caused by an explosion ("blast injuries"). Serological analysis identified the subject's blood group as O Rh positive. Bio-criminalistic examination involved two skin fragments from the head and one from the tongue, collected from the cadaver, subjected to a reaction with diphenylamine, with the following conclusion: the macroscopic examination of the skin fragments revealed the presence of possible intact hair strands; on the skin fragments collected from the head and the tongue, additional factors related to gunshot wounds were not identified, and the reaction with diphenylamine was negative.

The medico-legal report ultimately concluded the case as a violent death due to cardiorespiratory arrest resulting from exsanguination following severe craniofacial trauma. The traumatic injuries suffered, according to the investigative data provided, most likely occurred due to an explosion mechanism involving the use of a sound-emitting pyrotechnic device (a firecracker with a green fuse) placed in the oral cavity. It is noted that it is impossible to entirely rule out the possibility of these injuries occurring as a result of repeated, multiple direct blows, numbering over 20, with a hard-splitting object (such as a hatchet), some of which were applied post-mortem.

ON-SITE INVESTIGATION DESCRIPTION

According to the Police Ordinance, on September 6, 2021, at approximately 22:09 hours, an individual with a known identity was found deceased in his own residence, exhibiting certain injuries to the neck and face, leading to the preliminary conclusion that these injuries could have resulted from the bites of wild animals (specifically, a fox). The cadaver was subsequently retrieved and transported to the Institute of Forensic Medicine for autopsy. The provisional autopsy findings, released on September 7, 2021, indicated violent death due to hemorrhagic and traumatic shock resulting from multiple split facial wounds. In accordance with legal provisions [1], a new on-site investigation was conducted by teams of police officers and forensic experts on the same day.

During the new investigation, the following observations were made: the building had only one adjacent dwelling where no person was identified, the property consisted of two deteriorated residential structures, the entrance gate was found closed and not secured, a hair strand was identified on the gate handle's exterior, behind the two buildings, the fence was completely degraded and had fallen to the ground, providing easy access to the field, the windows on the door and windows were intact, except for one on the left side that was missing, with a wooden board nailed in its place, no signs of forced entry or intrusion were observed in the yard or the house, old spider webs were visible around the windows, the entrance door was secured from the inside with a piece of wood, the interior walls

of the building were degraded, blackened by smoke, and in some places, the plaster was missing, various waste items (household, bottles, cigarette butts, etc.) were identified inside the room, a small-sized handwritten note (agenda paper) was found on the table with the following message: "may you all reach the crematorium as i have suffered enough, let ash be the only thing left because i have come close to paralysis", on the adjacent nightstand: a blue pen and an agenda were found, in the nightstand drawer the following items were identified: a mobile phone, a synthetic leather wallet containing 26 RON and credit cards, a green fuse-type sound-emitting firecracker with serial number FS3/JM-BNG3, category PI, 3.5 grams, manufactured by LIUYANG JIMRY FIREWORKS CO LTD, imported by FIRESHOW SRL, a cardboard box labeled "sound-emitting device" and various documents, on the wall plaster in the middle of the bed, at a height of approximately 20 cm from the mattress, a zone with white-colored dust/powder was identified, no brownish-red substance stains relevant to the case were found in locations other than the two bedspreads on the bed and the pillow surface, under the two bedspreads on another traditional-patterned blanket multiple cardboard fragments possibly from an exploded firecracker were identified, no signs of disturbance or rummaging were observed.

No additional evidence or material means of proof were identified during the on-site investigation. It should be noted that the on-site investigation began at 12:05 and concluded at 14:40, conducted in both natural and artificial lighting conditions. Some of the forensic photographs comprising the photographic board can be found in Figure 2.

EXPERIMENTAL STUDY

Given the lack of scientific research in the field of sound-emitting pyrotechnic devices, as evident in existing literature reviews, which are also in line with the limited similar casuistry, it was deemed necessary to initiate this experimental study to elucidate several unknowns relevant for providing a more precise interpretation of the distinctive elements encountered in the case under the responsibility of our institute for medico-legal evaluation and conclusion formulation.

The primary objective of this experimental study is to assess the reactions of the explosive material under the influence of diphenylamine, a compound used to highlight secondary factors of gunshot injuries, both by procuring the powder directly from inside the pyrotechnic device and by testing the powder residue left on the material's surface and the cardboard fragment.

Furthermore, this experiment aims to confirm or refute the thermal effect of the pyrotechnic unit's activation. Additionally, we intend to estimate the projection distance of materials by the shockwave resulting from the explosion and to monitor the persistence of the odor resulting from the explosion in open space and its residual elements in closed space.

The experimental study was conducted in several locations, including an open space within a private property situated in the administrative-territorial unit of Targu Mures, Romania, with additional measures taken to minimize any possible discomfort or disturbance to individuals in the proximity of the experiment. It was also carried out in a closed space within the same private property and within the bio-

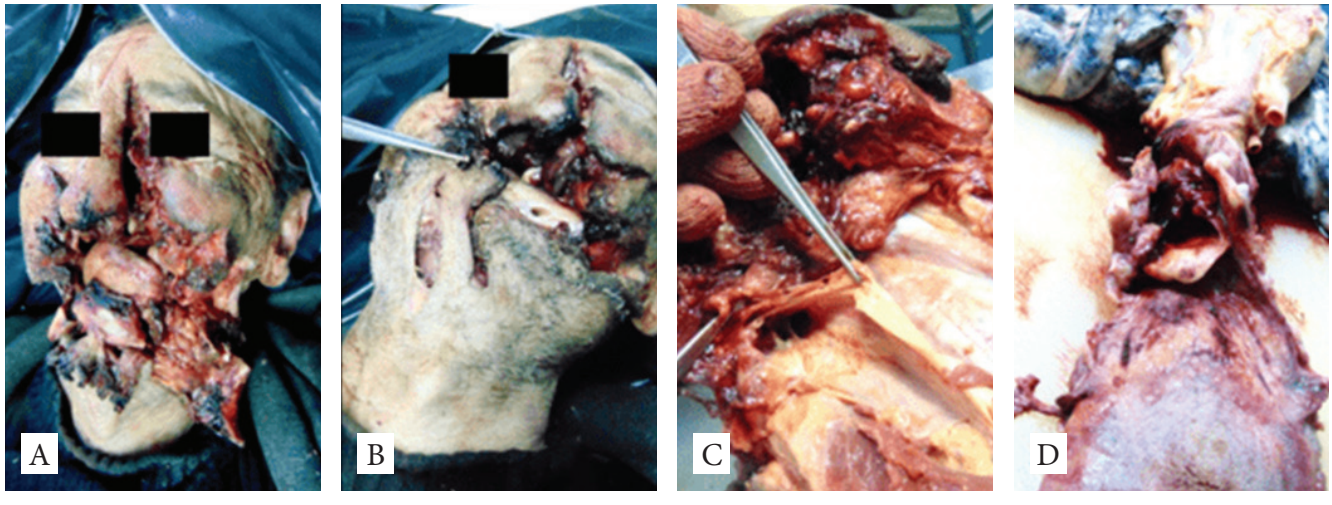

Figure 1. Images illustrating A,B - massive facial destruction; C - partial section of the right common carotid artery; D - hematic collection at the glottic orifice.

criminalistics laboratory of the Institute of Forensic Medicine in Targu Mures.

For the execution of the experimental study, the following materials were used: three sound-emitting devices FS3, P1, with a net explosive content (NEC) of 3.3 g, FIRESHOW brand, a stove igniter-type lighter, a black metal values box measuring 25x18x9 cm, a standard-sized A4 white sheet of paper, diphenylamine solution, three clock-type glass containers, a knife blade, a photographic apparatus, and a video camera.

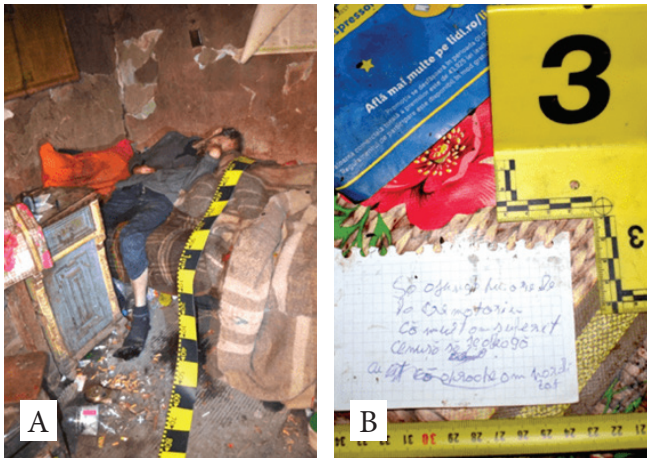

Figure 2. A - photograph taken at the scene, B - farewell note.

Figure 3. Preparation for the first phase of the experiment.

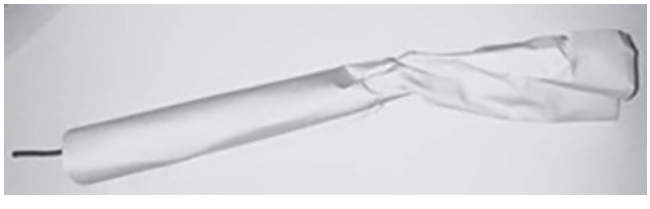

Figure 4. Preparation for the second phase of the experiment.

The actual conduct of the experimental study can be divided into two phases as follows. Phase 1: The first phase of the experiment involved igniting the fuse of the pyrotechnic unit and placing it inside the metal box as depicted in Figure 3, followed by closing the box and observing the explosive effect. After the explosion, the elements of the box and the cardboard remnants from the firecracker's casing were identified, and the distance from the explosion site was calculated. In the same location, the duration of the odor resulting from the explosion remaining perceptible in the air was timed in a subjective manner, with periodic assessments at 15-minutes intervals. Furthermore, the cardboard fragment resulting from the explosion and the powder from inside the metal box were collected and placed in a glass container along with 10 ml of diphenylamine to highlight the reaction to secondary factors. For a more critical comparison, explosive material from inside an unused pyrotechnic device was collected and subjected to the same diphenylamine reaction. Finally, the metal box was placed in a closed room, and the time during which it emitted a detectable odor within the room was recorded subjectively, with periodic assessments at 15-minute intervals. Phase 2: The second phase of the experiment was conducted by wrapping a pyrotechnic unit with a standard-sized A4 sheet of white paper, ensuring visibility and accessibility of the fuse, as illustrated in Figure 4. Subsequently, the fuse was ignited, and observers moved to a distance of approximately 20 meters from the pyrotechnic device, from where they observed the explosive effect. This was followed by an identification and photography phase of the residual elements.

As a result of the experimental study, the following outcomes were obtained: displacement and deformation of the metal box, with damage to its internal surface, due to the explosive wave [2], detachment of the box lid and closing mechanism elements, the distance of the elements involved in the explosion during the first phase of the experiment from the explosion site is illustrated in the positioning diagram in Figure 5, displacement and fragmentation of the A4 paper and the cardboard casing of the pyrotechnic device, persistence of the explosion odor in the air at the explosion site: 1 hour and 45 minutes, persistence of the odor of the box involved in the explosion in the ambient air of a closed

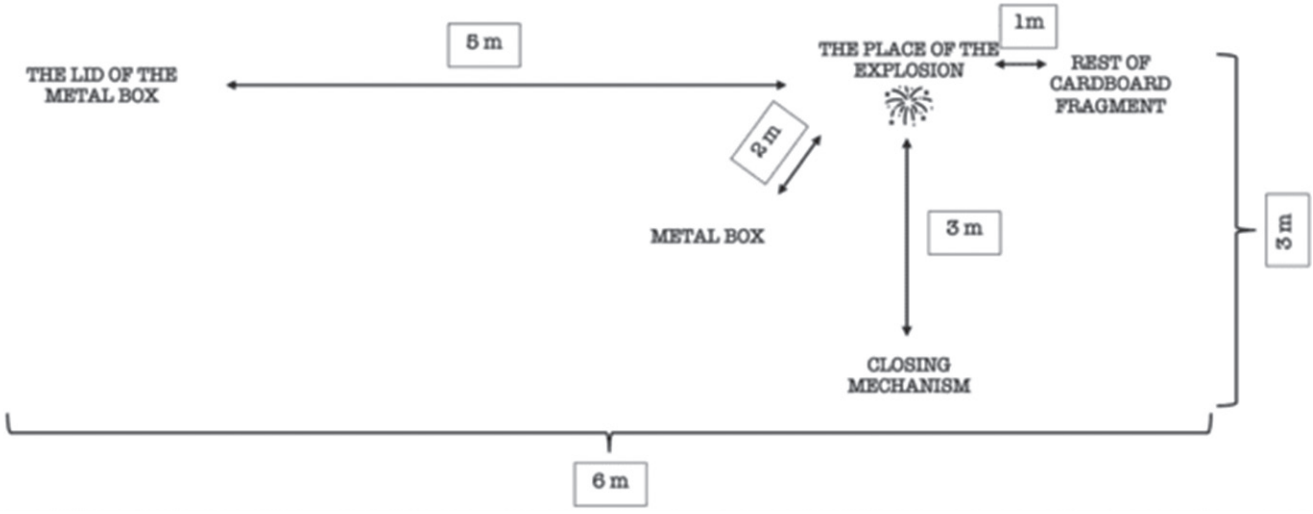

Figure 5. Positioning diagram of fragments resulting from the explosion of the firecracker in the first phase of the experiment.

Figure 6. Cardboard remnants found during the on-site investigation.

Figure 7. Cardboard remnants from the firecracker used in the first phase of the experiment.

Figure 8. Paper fragment left behind after the explosion in the second phase of the experiment.

space: 24 hours, negative reaction to diphenylamine of the cardboard fragment resulting from the explosion in the first phase of the experiment, negative reaction to diphenylamine of the powder collected from inside the box, negative reaction to diphenylamine of the powder from inside the unused pyrotechnic device.

Both the discussion and the conclusions regarding the aspects revealed through this experiment will be addressed in the discussion section for a more comprehensive descriptive and comparative analysis.

DISCUSSION

Identification and analysis of cardboard fragments from the firecracker casing

During the autopsy, no cardboard fragments from the firecracker casing were detected, a common aspect in cases involving explosive elements of this type, as described in the literature. To clarify this aspect, our attention turned to the investigation data. In the on-site investigation report, it is noted that "several cardboard fragments, possibly from an exploded firecracker, were identified on another traditional motif blanket," and the photographic board includes Figure 6, where three cardboard fragments can be observed, with uniform, relatively well-defined edges and no color changes. It is also mentioned that these fragments were located in the immediate vicinity of the deceased. In the experiment we conducted, the explosion resulted in the irregularly shaped, discontinuous cardboard fragment illustrated in Figure 7, with frayed, jagged, uneven edges and black discoloration at one end. Comparatively analyzing these two images, we can conclude that the cardboard fragments were most likely removed from the explosive material by the perpetrator before

Figure 9. Appearance of the right buccal wounds.

Figure 10. Appearance of mandibular bone fractures.

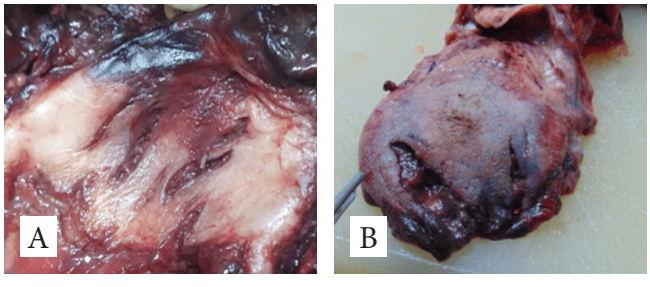

Figure 11. A – appearance of the hard palate, B – appearance of the tongue.

committing the act. This explanation would confirm the absence of cardboard material from the cavities of the body observed during the medico-legal autopsy. Furthermore, the literature [3-5] describes finding fragments of the casing material in the majority of cases when examining the deceased person.

Comparing Figure 7 with any image illustrating the appearance of cadaveric injuries, we can observe the presence of a blackish deposit on both the cardboard fragment and the skin and mucous membranes of the deceased. This deposit represents a layer of soot, primarily composed of a fine layer of carbonized material and other residues, formed as a result of incomplete combustion or oxidation during explosion. It should be noted that the presence of soot does not necessarily imply the existence of cutaneous burns.

The second part of our experimental study focused on testing the thermal effect of the explosion resulting from the activation of the pyrotechnic device. In the course of this phase, we observed the displacement and fragmentation of the A4 paper with which the firecracker was wrapped, resulting in a paper fragment measuring 20 x 12 cm, illustrated in Figure 8. The integrity of the paper, as well as its preservation of the white color, indicates that the explosive effect of the pyrotechnic device is not accompanied by a thermal effect. Therefore, the combustion that occurs inside the unit before the explosion does not involve the burning or thermal damage of tissues. Hence, the injuries caused by the intraoral explosion of the firecracker are not associated with thermal burns, a fact confirmed by the results of the histopathological report.

Discussion of right buccal wounds

During the external examination of the cadaver, in the course of the medico-legal autopsy, we noted the presence of two wounds with regular, straight edges and sharp angles, without blood infiltrate, with a depth of approximately 0.3 cm, both with a clean, whitish base, oriented from medial to lateral, as illustrated in Figure 9. The morphological characteristics of these wounds suggest that they were likely caused by cutting with a sharp-edged object, acting on the post-mortem body.

Due to the need for differentiation and the sometimes very similar appearance, the literature [6,7] distinguishes between injuries caused by the action of

Table 1. Characteristics of injuries caused by cutting and those due to the blast wave

Lesion Type	Mechanism of Production	Margins	Depth	Tissue Bridges	Hair Strands
Laceration	Blast wave	Often irregular	Variable	Present	Can traverse wound
Cut wound	Cutting	Regular, smooth	Sometimes uniform	Absent	Cut, separated

a cutting object and those caused by the blast wave, describing the characteristics presented in Table 1.

Thus, by analyzing the lesion appearance and reviewing the literature, we can formulate the hypothesis of a rupture/laceration of the avascular epidermis due to its stretching under the action of the explosive force. The visible tissue through the wound dehiscence is represented by the connective tissue of the dermis.

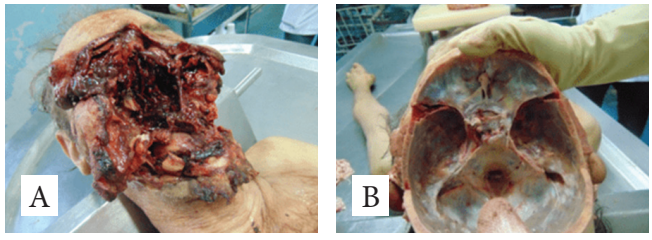

Figure 12. Appearance of osseous lesions of the viscerocranium and endobasis.

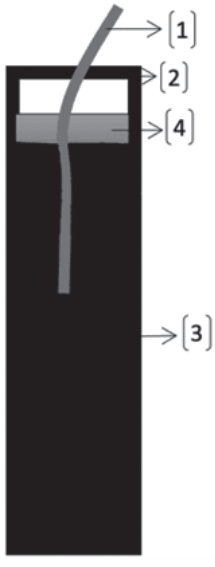

Figure 13. Constituent elements of the FS3/JM-BNG 3 pyrotechnic unit: (1) Ignition fuse; (2) Outer casing; (3) Explosive powder; (4) Chromatic effect powder.

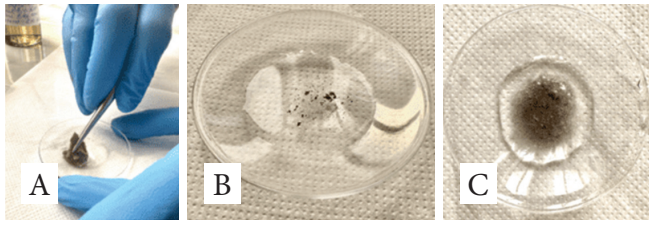

Figure 14. Diphenylamine reaction performed in the first phase of the experiment, in the order described.

Analysis of lesions under the aspect of symmetry and shape

Upon closer examination of the cadaver, in addition to the massive maxillofacial destruction, there is an asymmetric orientation of some of the traumatic lesions, contradicting the symmetry of others and, moreover, not matching the appearance of similar cases described in the literature [8-10]. We emphasize in this regard the trajectory from superomedial to inferolateral and the regular shape with linear edges and a sharp superior angle of the left paranasal wound with frontal extension, whose morphology and topography we consider atypical in the context of an intraoral explosion mechanism. Similarly, we can note the significant involvement of the left buccal region compared to the right, easily observed in Figure 1.A. These elements suggest the placement of the firecracker in a left lateral position in the oral cavity, so that the shockwave radiates from that point, providing the relative asymmetry observed during the external examination. This aspect cannot be entirely denied but is in contradiction with the parallelism of the wounds on the hard palate.

Regarding the fractures of the mandibular body, illustrated in Figure 10, which divide it into 4 fragments, we can say that they are discordant with the lesion pattern of an explosion due to their small number and large size of the visible mandibular fragments during the autopsy; cited sources [4,11] illustrating multiple fragmentation of the mandibular bone structure.

In contrast to the asymmetry of the above lesions, we describe the presence of 5 wounds located on the hard palate, illustrated in Figure 11.A, with a slightly oblique trajectory from anteromedial to posterolateral, parallel to each other, with regular edges and sharp angles, blood infiltrate, revealing the underlying tissue through wound dehiscence. These wounds are similar to the 5 lingual wounds with a similar trajectory, observable in Figure 11.B, both suggesting a radial blast wave, as described in the specialized literature [12].

It should be noted that the literature describes the asymmetric nature of injuries resulting from intraoral explosions in only one case [13].

Fracture of the anterior cranial base, with a linear trajectory, along with the ethmoidal blade fracture

Table 2. Chemical composition of the explosive powder

Composition	Chemical Formula	Percentage	Action
Potassium Perchlorate	$KClO_4$	50%	Acts as an oxidizer.
Aluminum and Magnesium Alloy	Al+Mg	25%	Acts as a fuel with a lower ignition temperature and shorter burn time, promoting complete particle combustion.
Sulfur	S	15%	Lowers the ignition temperature.
Flash/ Silvery Powder	$KClO_4$+Al	10%	Acts as a fuel.

and the multifragmentary visceral cranial fracture, illustrated in Figure 12, correspond to the mechanism of intraoral explosion, as described in many cases in the literature and even within a cranial mold experiment [9,11].

Analysis of secondary factors in gunshot wounds

The assimilation of ballistic powders resulting from firearm discharge with the explosive material discovered within a sound-emitting pyrotechnic device, is investigated to validate their impact in close proximity or even within the victim's body [14,15]. Particles of uncombusted or partially combusted powder on the skin can be identified using diverse techniques, encompassing examination under ultraviolet or infrared light, histopathological assessment of the skin, and chemical approaches involving reaction to diphenylamine.

The histopathological examination of tissue fragments obtained from the deceased in this specific instance did not substantiate the existence of gunshot residues (powders). Instead, it delineated a polymorphic, heterogeneous, and multifocal appearance, characterized by zones of discontinuity/ulceration. Certain of these features were linked to hematic infiltrates and regions of tissue necrosis in the proximate surroundings. This collective profile might suggest injuries stemming from an explosion, frequently denoted as "blast injuries."

During the forensic autopsy, a supplementary bio-criminalistics examination was executed. This evaluation encompassed the utilization of diphenylamine reactivity on two skin fragments from the head and one from the tongue, all procured from the deceased. The conclusions stemming from the bio-criminalistics analysis indicated the subsequent findings: within the macroscopic evaluation of the skin fragments, the presence of conceivably intact hair strands was ascertained. Nevertheless, the analysis of the skin fragments from the head and tongue did not expose any supplementary factors associated with gunshot injuries, as the response to diphenylamine was negative.

It is worth mentioning that literature describes [16] a specific component of the powders found in the structure of a sound-emitting pyrotechnic unit, given its different role compared to other pyrotechnic devices, namely its use to generate a colored and auditory visual effect aimed at deterring animals.

In accordance with the official document [17] on the chemical composition of sound-emitting pyrotechnic units of the FS3/JM-BNG 3 type, a unit similar to the one used in the discussed case, they consist of explosive powder and red color effect powder. This chemical composition is accompanied by the ignition fuse and the outer casing, as shown in Figure 13. The explosive material consists of potassium perchlorate 50%, aluminum and magnesium alloy 25%, sulfur 15%, and gray "flash" powder 10%, with the latter composed of potassium perchlorate and aluminum. Each chemical element has a well-defined role in generating the explosive effect, as detailed in Table 2. The red color effect powder contains 42% potassium perchlorate ($KClO_4$), 20% aluminum and magnesium alloy, 20% strontium carbonate ($SrCO_3$), 10% polyvinyl chloride (PVC), 4% phenolic resin ($C_{48}H_{42}O_7$), and 4% natural resin of animal origin, known as "Shellac" ($C_{16}H_{24}O_5$). The aluminum and magnesium alloy, in the composition of the chromatic effect powder, produces the characteristic popping sound and intense light effect [18].

Knowing the composition of the explosive powder, we conducted a test of reaction to the diphenylamine on three elements in the experimental study: the cardboard fragment resulting from the explosion in the first phase of the experiment, powder collected from inside the metal box, and explosive material from inside an unused pyrotechnic device. The three elements were added to a glass container with a watch glass that contained 10 ml of diphenylamine, and the following effects were observed, according to Figure 14:

- Reaction of the cardboard fragment resulting from the explosion in the first phase of the experiment: negative.

- Reaction of the powder collected from inside the box: negative.

- Reaction of the powder from inside the unused pyrotechnic unit: negative.

Therefore, through the totality of the analysis methods used, we can conclude that the powder that makes up the explosive material in a sound-emitting pyrotechnic device does not resemble ballistic powders from firearms, and it does not contain nitrate compounds that would allow a positive diphenylamine reaction. Therefore, the assessment of secondary factors of gunshot injuries does not prove to be relevant in the case of a death caused by the intraoral explosion of a pyrotechnic device.

In conclusion, we can orient our opinion in two directions, namely regarding aspects that may

indicate homicide, followed by intraoral placement and ignition of a pyrotechnic unit for its concealment, or the necroptic and investigative elements that support the hypothesis of suicide. Following the exhaustive analysis of all the data in this study, pertinent arguments can be made for each of these hypotheses.

Aspects that may indicate homicide include:

- The morphology and topography of the cut-split wound located in the left paranasal area with regular margins and a sharp superior angle, as well as the atypical trajectory it presents from superomedial to inferolateral on the left, which does not correspond to the typical symmetry of injuries caused by the blast wave of an explosion.

- The appearance of buccal wounds and the submental wound located paramedian right, devoid of infiltrate, with the possibility of their postmortem production.

- The absence of a description of tissue fragments projecting onto the room surfaces.

- The provision of erroneous information during the medico-legal examination process that could modify its course, specifically the announcement to the institute that the deceased person was "bitten by animals".

- The lack of meticulous on-site investigations, supporting the provision of advantages to the perpetrator.

- The discrepancy between the position of the corpse, the location of bloodstains, and the placement of traces of pyrotechnic material resulting from the explosion.

- The relatively low probability that the deceased person was aware of this method of suicide, considering that it has been documented only once in Romania and with low frequency internationally.

- The linear and regular trajectory of mandibular fractures and the small number of resulting fragments, suggesting more of a splitting mechanism.

Aspects supporting the suicidal act, include:

- An alcohol level of 0.14 g per mille, even though the value is not significant; it is known that suicidal individuals tend to consume alcoholic beverages or administer psychiatric medications to facilitate the final decision to end their own lives.

- The existence of a handwritten farewell note with the message "may you all reach the crematorium as i have suffered enough, let ash be the only thing left because i have come close to paralysis".

- The absence of signs of forced entry or destruction at the points of access to the residence.

- The discovery of the entrance door blocked with an improvised locking system.

- The unsanitary and neglected state in which both the deceased and his living space were found, indicating that the person did not care for themselves and did not have close contacts to take care of them; these factors are important in assessing the social support received and self-respect.

- The existence of a description in the literature of a case of death due to intraoral explosion of pyrotechnic material characterized by asymmetrical traumatic injuries.

- The absence of an obvious motive to justify committing a crime for personal gain.

- The absence of identification of a hard object in the building or nearby that could have caused the fatal blows.

Controversies between the two hypotheses could have been easily resolved if the following essential aspects for solving the case had been available during the investigation:

- Graphoscopic expertise of the farewell note to assess its authenticity.

- Outlining the graphological profile and evaluating the mental state of the person at the time of writing through graphological expertise.

- Dactyloscopic expertise to analyze fingerprints present in the residence.

- Description of the smell in the room upon initial entry by the investigative team (considering that in our study, the smell persisted for 24 hours in a closed space, and the literature [4,10] describes the detection of the characteristic odor in rooms where the explosion occurred).

- Ballistic expertise of the firecracker found in the person's drawer to determine or estimate the explosive force [2] according to relevant physical algorithms, the distance of the fragments involved in the explosion (calculated in our study according to the positioning diagram in Figure 5), residual material composition of the pyrotechnic device, creating an experimental model for reconstructing the explosion moment [12], etc.

- Thermal analysis of the heat effect of the firecracker.

- Reconstruction of craniofacial features through the use of non-necroptic computerized means (e.g., virtual autopsy, CT scanning).

Therefore, it can be said that a detailed autopsy and the use of complementary histopathological and bio-criminalistic examinations, in such atypical

cases, including conducting an experimental study, are not sufficient to establish the cause of death. A comprehensive and meticulous on-site investigation is imperative, with the mandatory participation of a forensic physician, to correlate investigative data with the findings of the autopsy report in order to ensure the uniformity and absolute veracity of the facts.

Conflict of interest

The authors declare that they have no conflict of interest.

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