Gunshot injuries caused by pneumatic devices - a description of three cases

major
Maciej Kuliczkowski, PhD
expert
Weapons and Ballistics Testing Laboratory
Forensic Laboratory of the Police in Wrocław
ORCID: 0009-0008-4585-2545,
e-mail: maciej.kuliczkowski@wr.policja.gov.pl

Łukasz Szleszkowski, MD, PhD
forensic medicine specialist
assistant professor
Department and Institute of Forensic Medicine
Medical University in Wrocław
ORCID: 0000-0003-4539-0391,
e-mail: lukasz.szleszkowski@umed.wroc.pl

Identyfikator cyfrowy - https://doi.org/10.34836/pk.2025.321.1

Abstract

The article describes three cases of the criminal use of pneumatic pistols of different systems, calibres and manufacturers against people, resulting in injuries in the form of skin breaking and damage to the eyeball with the need for its removal. In each of the cases studied, the authors calculated the kinetic energy of the projectiles fired and the specific energy with which the projectiles interacted approximately with the bodies of the people fired at causing their injuries. The gunshot injuries are described by correlating them with the calculated specific energy values of the fired projectiles, referring to the human skin strength data reported in the literature at the level of 10 J/cm^2 (0.1 J/mm^2) and the strength of the eyeball with a lower puncture resistance limit. The specific energy of a projectile, defined as the ratio of the projectile's kinetic energy to its cross-sectional area, is given in Joules per cm^2 (as assumed in this article) or mm^2.

Keywords: pneumatic device, air gun, specific energy of the projectile, gunshot injuries

Introduction

The term 'pneumatic devices' refers to tools that use the force of compressed air, such as grinders, drills, pin setters and weapon-like devices designed to fire projectiles, in particular in the form of pistols, revolvers and carbines, which are colloquially referred to as 'pneumatic weapons'. However, according to the statutory definition in Article 8 of the Act of 21 May 1999 on weapons and ammunition, a pneumatic weapon is a device dangerous to the life or health which, as a result of the action of compressed gas, is capable of firing a projectile from the barrel or a component replacing the barrel and thus capable of striking a target at a distance, and the kinetic energy of the projectile leaving the barrel or the component replacing the barrel exceeds 17 J. In view of the above, devices which, as a result of the action of compressed gas, are capable of firing a projectile from the barrel and of striking a target at a distance, and the kinetic energy of the projectile leaving the barrel does not exceed 17 J, do not meet the statutory definition of a pneumatic weapon, are not subject to the provisions of the cited Act, and consequently are not regulated by the State, and their possession does not require registration. These devices, which are not pneumatic weapons within the meaning of the Act on weapons and ammunition, cannot therefore be referred to as such. In forensic and medical literature, so-called low-energy pneumatic devices designed to fire projectiles with kinetic energy not exceeding 17 J are referred to as 'pneumatic devices', as opposed to 'pneumatic weapons', which are pneumatic devices capable of firing a projectile with kinetic energy exceeding this value and are consequently subject to registration. The question arises as to whether the energy value of the fired projectiles, as indicated by the legislature, determines the danger to life or health that they may cause, or whether every pneumatic device constructed to fire projectiles is dangerous to life or health, and only one that is capable of firing a projectile with a kinetic energy in excess of 17 J requires a registration card issued by the competent governmental authority. It is worth noting that in the legislation of various countries, the values of the energy considered safe (low muzzle energy) for pneumatic devices vary within wide limits. Some countries have not set such a limit (e.g. Denmark, Finland, the Netherlands), while in others it is lower (e.g. up to 7.5 J in Germany, Hungary and Lithuania) or higher (up to 20 J in France and up to 24 J in Spain and Portugal) than in Poland. Pneumatic devices that do not require registration as pneumatic weapons have become very popular in Poland and, in addition, as they are not weapons, their use is not restricted to shooting ranges. Consequently, as evidenced by forensic and medical practice, they are often an instrument of crime and projectiles fired using them cause numerous injuries to both humans and animals. Cases of fatal shooting, whether manslaughter, suicide or homicide, are also known from numerous forensic and medical cases. The cases described below relate to pneumatic devices in the form of pneumatic pistols of various systems and calibres used against people, detailing injuries caused by fired projectiles, including a projectile fired from a large-calibre air gun designed as an incapacitating device not intended to break a person's skin and cause injuries more serious than superficial.

Case one

According to the data contained in the case file, on 19 July 2020 in Wrocław, in the morning, in front of the store named '303 Types of Beers', the shop assistant Maciej M. fired at, in his opinion, an intrusive, Grzegorz W., who was a homeless person. Maciej M. used a Taiwanese pneumatic pistol ASG CZ 75 D Compact cal. 4.5 mm, loaded with cal. 4.5 mm spherical copper-plated steel BB projectiles from an undetermined manufacturer, intended for pneumatic devices, fired using CO2 gas drawn from an interchangeable 12-gram cartridge. The perpetrator, standing at the threshold of the shop entrance, fired several shots in the direction of the victim, holding the pistol in his right hand. The victim, Grzegorz W., had the front part of his body turned towards the shooter and was located at a distance of approx 1 metre from the mouth of the pistol barrel. One of the projectiles hit Grzegorz W. in the left eye, causing swelling of the eyelids, a perforating wound of the eyeball in the upper-nasal quadrant with choroidal prolapse and ocular hypotony, resulting in damage to the left eyeball and requiring its removal. The victim was found sleeping on a bench with fresh blood visible in the conjunctival sac and on the lashes of the left eye. In the Ophthalmology Clinical Department of the Jan Mikulicz-Radecki University Clinical Hospital in Wrocław, as a result of CT scans of the head and craniofacial cavity, a metallic foreign body, 5 mm in diameter, was found in the left orbit of the victim, located in the posterior pole of the eyeball in the optic nerve projection. A penetrating wound in the left eyeball with a poor prognosis was found. In view of the absence of sense of light in the left eyeball and the presence of a foreign body extraocularly in the orbital apex, a combined ophthalmic and maxillofacial procedure was performed, in the form of enucleation of the eyeball and removal of the foreign body, subsequently handed over to the police. The body turned out to be a fired cal. 4.5 mm spherical steel projectile, copper-plated, of the BB type, from an undetermined manufacturer, intended for pneumatic devices. The forensic medicine specialist who gave his opinion in this case stated that the gunshot wound in Grzegorz W.'s left eyeball resulting in damage to the eyeball with the requirement of its removal resulted in other severe disability and permanent significant disfigurement to the victim within the meaning of Article 156 of the Criminal Code. The perpetrator of the shooting damaged the pistol: as he stated in his

ryc 1. The cal. 4.5 mm CZ 75 D Compact ASG pneumatic pistol, made in Taiwan, provided for testing.

explanations the pistol fell and broke, and he threw it into the mixed municipal waste. Despite this, the pistol was found, secured and submitted for weapons and ballistics testing. The Taiwanese cal. 4.5 mm CZ 75 D Compact ASG air pistol provided for testing had a damaged casing in the rear part imitating the breech and the skeleton of the pistol, in such a way that a fragment of it was missing at the base of the cock, which did not cause any dysfunction in the mechanisms of the pistol under examination and its ability to fire projectiles. The housing of the pistol was made of black plastic. Along with the pistol used as evidence, a magazine loaded with fourteen cal. 4.5 mm steel, copper-plated, BB type projectiles from an undetermined manufacturer, intended for pneumatic devices, was provided for testing, with a CO2 gas cylinder installed, which may indicate that the victim was shot with six projectiles. The projectiles removed from the magazine were weighed using a Radwag PS 1000.X2 electronic laboratory scale with an average result of 0.34 g. As the mechanisms of the pneumatic pistol used as evidence functioned correctly, in a manner indicating the possibility of firing cal. 4.5 mm spherical steel projectiles of the BB type intended for pneumatic devices using compressed CO2 gas drawn from interchangeable cylinders, performance tests were carried out on the pneumatic pistol, which involved firing twelve randomly selected projectiles used as evidence, using the CO2 gas cylinder used as evidence. During each shot, the velocity of the fired projectile was measured using an Emserwis mod. EMC-500 measuring device. The measurements showed that the value of the average initial velocity of the fired projectiles was 86.2 m/s, while the lowest and highest values of their initial velocity were 74.4 m/s and 94.1 m/s. The calculations carried out showed that the value of the average initial kinetic energy of the fired projectiles was 1.26 J, the lowest value of the initial kinetic energy of the fired projectile was 0.94 J, and the maximum energy of the fired projectile measured in the course of the tests carried out was 1.5 J. As more than seven weeks had elapsed between the time of the incident and the date of the examination of the pistol, a further test of the pneumatic pistol was carried out, involving the firing of the same projectiles (projectiles in a collective pack used as evidence were seized from the suspect) through the gates of the aforementioned measuring device, using a new CO2 gas cylinder. The following results were obtained: the average value of the initial velocity of the fired projectiles Vavg. = 78.5 m/s, the highest value of the initial velocity of a fired projectile Vmax. = 83 m/s, the average kinetic energy of the projectiles fired Eavg. = 1 J, the maximum kinetic energy of a fired projectile Emax. = 1.17 J. The ability of a projectile to penetrate a material, causing injury and damage, is determined by the specific

energy of the projectile (the relative kinetic energy of the projectile), defined as the ratio of the projectile's kinetic energy to its cross-sectional area. Publications on the strength of human skin state that it is can be perforated by projectiles having a specific energy greater than 10 J/cm², and for the eyeball this limit is 6 J/cm². Forensic literature also states that severe and dangerous injuries, in particular cranial bone perforations, can be caused by a projectile with a kinetic energy of not less than 7.5 J or at least 0.5 J/mm² of relative kinetic energy. In view of the above, an attempt was made to calculate the specific energy of the fired projectile, which caused the perforation of Grzegorz W.'s eyeball, on the basis of the results of the evidence obtained: the pneumatic pistol, the projectiles and the CO2 gas cylinder. The average value of the specific energy of the projectiles fired from the pneumatic pistol used as evidence was 7.9 J/cm² (0.079 J/mm²), the minimum value of the specific energy of the projectile fired was 5.87 J/cm², with the maximum value of the specific energy of the projectile fired being 9.37 J/cm², which gives rise to the assumption that the specific energy of the projectile that struck the left eye of the victim was within this range of values. Maciej M, who was accused and detained on remand, was found guilty, in the verdict issued by the Regional Court in Wrocław, of causing the injured person, Grzegorz W., another severe disability and permanent significant disfigurement, i.e. of committing an act under Article 156 (1) (2) of the Criminal Code, and was sentenced to 1 year in prison and punitive damages of PLN 4,000 in favour of the victim.

ryc 2. The cal. 4.5 mm spherical steel projectile, of the BB type, intended for pneumatic devices, extracted from the victim's left eye socket.

Case two

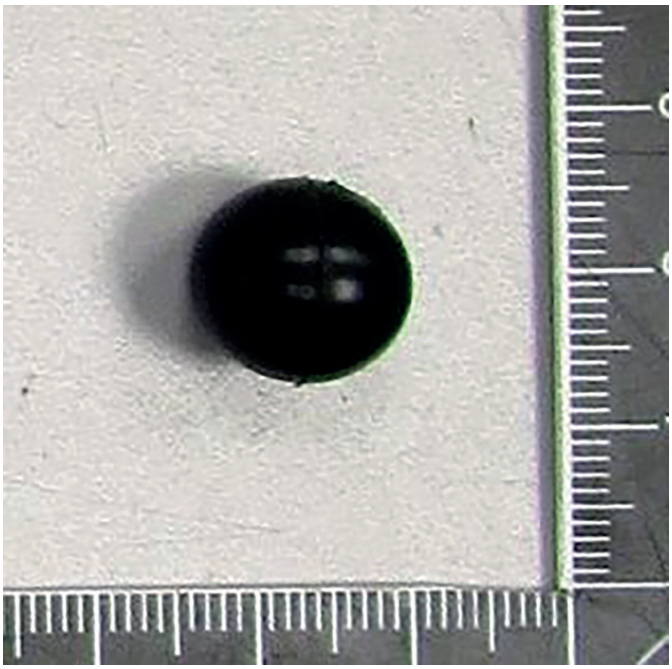
On 15 July 2022 in Wrocław, a young man went to a courtyard of tenement houses to shoot a Chinese cal. 4.55 mm b/n Kandar Model S3 single-shot pneumatic pistol he owned, as he explained, at rubbish bins located in the middle of the courtyard. The man used cal. 4.5 mm Diabolo type projectiles from various manufacturers, intended for pneumatic weapons and devices. Children playing in the area became interested in the shooting and approached the shooter. One of them, less than nine-year-old boy Marcin C., suffered a gunshot wound to the chest because, as suspect Damian B. explained, he ran into the line of fire. The data contained in the medical records relating to Martin C. indicate that this boy was admitted to a hospital with a gunshot wound to the chest. There was a visible entry wound located at the level of the left nipple, approx. 5 mm in diameter. A CT scan of the chest revealed a visible metallic body located at the level of the 3rd rib, not penetrating the chest, approx. 8 mm in size - in the subcutaneous tissue of the anterior chest wall on the left side, at a depth of approximately 1.3 cm from the skin surface. Under general anaesthesia, the wound was checked and the 'shot', located subfascially, was removed and handed over to the police. The projectile extracted from the wound was 6.5 mm long. The boy was diagnosed with obesity. The pneumatic pistol used as evidence, the projectiles seized from the suspect and the projectile handed over by medical personnel and used as evidence were sent for examination. The pneumatic pistol, cal. 4.5 mm b/n Kandar Model S3, made in China, was complete and had a rifled barrel with twelve right-handed grooves, seated pivotally downwards in the piston chamber. The tested pneumatic pistol bore no signs of unauthorized modifications and its mechanisms worked properly, in a manner indicating that it could fire cal. 4.5 mm projectiles, in particular of the Diabolo type, intended for pneumatic weapons and devices, using compressed air. The projectile extracted from the wound Marcin C. and used as evidence was a cal. 4.5 mm, Diabolo type projectile intended to be fired from pneumatic weapons and devices. This lead-alloy projectile was weighed using a Radwag PS 1000.X2 electronic laboratory scale with a result of - 0.49g. The projectile had a rounded tip and a smooth lower part (the so-called tail) and its design corresponded to the Czech-made 'Diabolo Boxer' projectiles seized from the suspect. In order to determine the initial energy of the projectiles fired from the pneumatic pistol and to obtain comparative material for further identification tests, twelve cal. 4,5 mm 'Diabolo Boxer' projectiles, made in the Czech Republic, intended for pneumatic weapons and devices, were fired from the pistol, with simultaneous measurement of their initial velocities using the Emserwis EMC-500 measuring device. Three shots were fired into a projectile interceptor filled with cotton batting, thus ac-

ryc 3. The pneumatic pistol, cal. 4.5 mm b/n Kandar Model S3, made in China, provided for the testing.

quiring comparison projectiles for further identification tests. The measurements showed that the value of the average initial velocity of the fired projectiles was 109.9 m/s, the lowest initial velocity of the fired projectile was 105.7 m/s, and the value of the highest velocity of the fired projectile was 113.4 m/s, which allowed the calculation of the average value of the initial kinetic energy of the fired projectiles at the level of 2.9 J, the lowest initial kinetic energy of the fired projectile at the level of 2.73 J and the maximum initial kinetic energy of the fired projectile, which was equal to 3.15 J. Based on the results, the approximate specific energy of the projectile that pierced the skin of the boy's chest and penetrated a blind channel in the subcutaneous tissue with a total length (i.e. including the projectile) of approximately 13 mm was calculated. This energy, calculated based on the average value of the initial kinetic energy of the fired projectiles, was 18.1 J/cm^2, 17 J/cm^2 for the lowest value of the initial kinetic energy of the projectile fired and 19.6 J/cm^2 for the highest value of the initial kinetic energy of the projectile fired during the test. The forensic medicine specialist who issued his opinion in this case stated that the injuries sustained by Marcin C. in the form of a gunshot wound to the chest on the left side were other than those specified in Article 156 of the Criminal Code and caused medium damage to health in the form of a violation of bodily organ functions or a disorder of health lasting longer than seven days within the meaning of Article 157 (1) of the Criminal Code. Furthermore, responding to

ryc 4. The cal. 4.5. 'Diabolo Boxer' projectile, made in the Czech Republic, intended for pneumatic weapons and devices, extracted from a gunshot wound to the victim's chest and used as evidence.

ryc 5. The cal. 12.7 mm (50'') Umarex T4E HDP 50 pneumatic pistol, made in Germany, provided for testing.



ryc 6. The cal. 12.7 mm (.50'') spherical rubber projectile with metallic fines (steel particles) from an undetermined manufacturer extracted from a gunshot wound in the victim's chin.

a question from the principal, this expert replied that the perpetrator's action of firing a projectile of the specified parameters and design into the anterior chest wall of the injured person caused him to be exposed to an imminent danger of loss of life or serious harm to health under Article 160 (1) of the Criminal Code.

Case three

On 17 July 2022 in Świdnica, an intoxicated 29-year-old man, Michał S., returning from the Żabka shop in a square, attempted to harass two young Ukrainian women. Michał K. armed with a cal. 12.7 mm (50'') Umarex T4E HDP 50 pneumatic pistol, made in Germany, loaded with cal. 12.7 mm (50'') spherical composite (rubber-metal) projectiles from an undetermined manufacturer. According to the suspect Michał K.'s explanations, there were five such projectiles in the magazine of the pistol (the magazine allowed six projectiles to be placed in it). In order to fire the shots, Michał K. punctured the diaphragm of theCO_2 gas cylinder head located in the grip of the pistol by hitting his knee with the screw head of the gas cylinder socket and then, as he stated in his explanations, fired a warning shot into the air and, in the absence of a reaction from the attacker, fired in the direction of the man's chest. He fired this shot from a distance of approximately 1 metre. The shot supposedly only irritated the

advancing Michał S. so the shooter fired the three projectiles remaining in the magazine in the attacker's direction, as he claimed, aiming at his chest. A scuffle ensued between the two men and Michał K. used the pistol held in his hand as if it were a blunt weapon. As a result of the incident, Michał S. sustained facial injuries typically caused in an active mechanism as a result of being struck with a fist or a similar hard and blunt instrument, an abrasion of the epidermis accompanied by a subcutaneous haematoma in the parietal-occipital region of the head as a result of the victim being struck with a pistol, and two gunshot injuries. One of them, in the projection of the sternal end of the right clavicle, took the form of a deep, brown scab-covered abrasion of the epidermis with a diameter of 1,3 cm, centrally located within a pink discolouration with a diameter of 3 cm, surrounded by a circular, bluish, moderately saturated bleeding abscess with a diameter of 4 cm and a thickness of approximately 0,7 cm (data from the forensic medical examination of the body of the shot person conducted on 19 July 2022). The injury was caused by the impact of a fired projectile, which, after hitting the victim's chest, caused a bloody abscess and an abrasion of the epidermis and rebounded off the fired surface, without causing a puncture of the skin layers. A second gunshot wound was found in the victim's chin in the form of an entry hole surrounded by an abrasion wound, described in the forensic medical examination of his body as 'located on his chin, in the medial line of his body, a wound of 1.3 cm in diameter, covered with a brown scab, accompanied by a circular epidermal abrasion of approximately 1.6 cm in diameter'. The CT examinations of the head and facial skeleton showed an oval foreign body shadow in front of the mandible with metallic saturation, approximately 12 mm in diameter. In view of the above, the gunshot wound to the chin area was reviewed by removing the 'bullet' described as having been revealed under the skin on the chin of the victim Michał S. and handed over to the police. The projectile extracted from the wound was subjected to weapons analysis testing, which confirmed that it was a black-coloured composite spherical projectile, i.e. rubber filled with metallic dust (steel particles), cal. 12.7 mm (.50'') of an undetermined manufacturer, weighing 2.64 g. The projectile was not suitable for comparative identification testing due to its material (rubber with metallic fines). The subject of the weapons and ballistics tests was also the cal. 12.7 mm (50'') Umarex T4E HDP 50 pneumatic pistol, made in Germany, seized from the suspect together with a CO2 gas cylinder and cal. 12.7 mm (.50'') projectiles from an undetermined manufacturer with an average weight of 2.64g. The projectiles were in a package with a label containing printed inscriptions stating, among other things: 'COMBAT Steel Demon RAM rubber-metal bullets cal. 50, 100 pcs'. In order to determine the initial energy of the projectiles fired from the cal. 12.7 mm (50'') Umarex T4E HDP pneumatic pistol, made in Germany, six projectiles used as evidence were fired (the pistol's magazine was fully loaded) with simultaneous measurement of their initial velocities using an Emserwis EMC-500 measuring device. The measurements showed that the value of the average initial velocity of the fired projectiles was 109.5 m/s, and the value of the highest velocity of the fired projectile was 112.7 m/s, which made it possible to calculate the average value of the initial kinetic energy of the fired projectiles at 15.8 J, and the maximum initial kinetic energy of the fired projectile at 16.76 J. Based on the results obtained, the average specific energy of the projectiles was calculated at 12.5 J/cm^2, and the maximum specific energy of the projectile with the highest initial velocity at 13.3 J/cm^2. The projectile with the lowest tested initial velocity of 107.1 m/s interacted with the surface fired at with a specific energy of 12 J/cm^2. The specific energy of the two projectiles, which wounded the victim in the chest without causing skin perforation and the face in the region of the chin causing skin disruption in the form of an entry hole and a shallow blind canal with the projectile lodged in the skin in front of the jaw, may have been in this range of values. The forensic medicine doctor who issued his opinion in the case stated that the firing of the pistol operated with 'rubber bullets' in the direction of Michał S.'s face, which resulted in a breach of the continuity of the skin and the projectile becoming lodged in the wound in his chin, exposed him to the risk of serious damage to his health in the form of depriving him of his sight, explaining that piercing the skin requires more force than damaging the eyeball. As the expert explained, if the eyeball had been hit by a projectile of approximately 12 mm in diameter with an energy such as that of the projectile lodged in a chin wound, there would have been a break in the continuity of the sclera, the outflow of the vitreous fluid of the eye and consequent loss of vision in the hit eye.

Conclusion

The cases of the use of pneumatic pistols against people described herein prove that so-called low-energy pneumatic devices are capable of causing injuries to humans, including serious ones, especially when the projectile is fired from a relatively short distance. The results of the tests are correlated with the data from the forensic medical examinations, in which cases of fatal shootings can also be found. A cal. 4.5 mm spherical steel projectile of the BB type shot from a pneumatic pistol using compressed CO2 gas from a replaceable gas cylinder with a kinetic energy of approximately 1.26 J was capable of penetrating the eyeball, resulting in severe injury to the victim. In the other two cases, a cal. 4.5 mm Diabolo type projectile and a cal. 12.7 mm spherical rubber projectile containing metallic fines, fired from a pneumatic pistols with an approximate kinetic energy of 2.9 J and 15.8 J, respectively, after hitting skin layers, pierced them, creating shallow blind shot channels. The perpetrators of these shootings were charged with causing medium bodily harm and putting a person in imminent danger of serious bodily harm. Of particular interest is the penetration of skin layers by a large-calibre composite projectile designed and advertised as a safe form of defence without the potential to cause a serious injury, including perforation of human skin. The calculated average specific energy values of the fired projectiles confirmed the limit values reported in the literature for the puncture resistance of skin layers and the eyeball and were 7.9 J/cm² for the eyeball and 18.1 J/cm² and 12.5 J/cm² for the skin. These findings may be important in the evaluation process, particularly given the prevalence of pneumatic weapon-like devices and their consequent use against humans. For forensic medicine specialists, they provide valuable material both for forensic medical evaluations on the direct consequences of gunshots (Articles 156 and 157 of the Penal Code) and the potential and highly likely consequences in the context of evaluations on the exposure to direct danger of loss of life or serious injury to health (Article 160 of the Penal Code).

Akty prawne

1 Act of 21 May 1999 on arms and ammunition (consolidated text: Journal of Laws of 2015, item 1505).

Bibliography

1. Bogiel G., (1997). Podstawowe problemy balistyki zranień. Problemy Kryminalistyki, 215.
2. Bukowiecka D., Wojciechowski M. (2015). Badanie prędkości pocisków o niskiej energii. Wydawnictwo Wyższej Szkoły Policji w Szczytnie.
3. Dobosz T., Jaworski R., Kawecki J., Semiczek W., Trnka J. (2002). Wzmacnianie („rasowanie") amunicji kalibru 4 mm typu M 20. Archiwum Medycyny Sądowej i Kryminologii, LII.
4. Kamphausen Th., Janßen K., Banaschak S. , Rothschild M.A., (2019) Wounding potential of 4.4-mm (.173) caliber steel ball projectiles. International Journal of Legal Medicine (2019) 133:143–150.
5. Kobek M., Chowaniec Cz., Rygol K., Jabłoński Ch. (2011). Niezwykły przypadek postrzału z broni pneumatycznej. Archiwum Medycyny Sądowej i Kryminologii, LXI.
6. Konopka T. (1997). Możliwości powstania głębokich obrażeń przy użyciu miniaturowej broni palnej. Archiwum Medycyny Sądowej i Kryminologii, XLVII.
7. Litwin P.,Chagowski W. Smędra A., Postrzały z nietypowych rodzajów broni. w Medycyna Sądowa t.1 Teresińsiki G (red), Warszawa, PZWL, 599-604
8. Markiewicz D., Bartyzel B.J., Borusiński M., Bogiel G., Staszak A., Misiewicz J., Dierzęcka M., Wiśniewski J., Wybrane zagadnienia związane z użyciem broni palnej do przestępczego uśmiercania zwierząt. Problemy Kryminalistyki, 301.
9. Ng'walali P. M., Ohtsu Y., Muraoka N., Shigeyuki T. (2001) Unusual homicide by air gun withh pellet embolisation. Forensic Science International 124, 17-21.
10. Peschel O., Manthei A., Kühl Ch. (2005). Potencjalne obrażenia powstałe w następstwie stosowania amunicji markerów barwnych. Problemy Kryminalistyki, 249.
11. Petrus K., Angyal K., T´oth D, Soma Po´or V., Heckmann V., Simon G., (2023) Forensic assessment of a life-threatening penetrating abdominal air gun injury) Legal Medicine 60 102182.
12. Simon G., Heckmann V., Tóth D., Kozma Z. (2019) Brain death of an infant caused by a penetrating air gun injury. Legal Medicine 39 pp. 41–44.
13. Smędra-Kaźmirska A., Barzdo M., Kędzierski M., Szram S., Berent J. (2010). Doświadczalny efekt postrzału pociskami kalibru 4,5 mm wystrzeliwanymi z karabinka pneumatycznego Norica Dragon i pistoletu pneumatycznego Walther PPK/S. Archiwum Medycyny Sądowej i Kryminologii, LX.
14. Stankov A., Jakovski Z.,Pavlovski G., Muric N., Dwork A.J.,Cakar Z. (2013) Air gun injury with deadly aftermath – Case report Legal Medicine 15 pp.35–37.
15. Stępniewski W., Mówiński G., Sokół, W. (2006). Doświadczalny efekt biologiczny postrzału pociskami kalibru 4,5 mm BB z pistoletu pneumatycznego A-101. Archiwum Medycyny Sądowej i Kryminologii, LVI.
16. Trnka J., Golema W.P., (2017). Przypadek samobójczego postrzału głowy z rewolweru hukowo-kinetycznego typu „Keseru" jako przykład niebezpieczeństw związanych z używaniem replik broni dostępnych bez zezwolenia. Archiwum Medycyny Sądowej i Kryminologii, 67.
17. Vaitkevičius, E., Kurapka, E., Malewski, H. (2003). Wybrane zagadnienia stosowania broni na naboje Floberta. Archiwum Medycyny Sądowej i Kryminologii. 53(4), 339-345.