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Sudden death due to malignant hyperthermia during general anesthesia

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The authors present a case of malignant hyperthermia. The article discusses the death of a 4-year old boy who appeared to be perfectly healthy and underwent dental treatment under general anesthesia. The procedure went well at the beginning, but suddenly complications developed, such as cardiac rhythm disorders and increased body temperature, subsequently, muscle rigidity appeared. Such symptoms are characteristic for an inherited disease called malignant hyperthermia. Despite professionally performed resuscitation and help of an emergency unit, the patient died.

Key words:

medico-legal opinion,
malignant hyperthermia,
general anesthesia

INTRODUCTION

Malignant hyperthermia is a very rare autosomal dominant genetic disease [1, 2, 3]. Its incidence is reported as one case per several thousand, less than twenty or even several score thousand general anesthesia procedures [3] and the condition may be fatal [1, 2]. Malignant hyperthermia is characterized by an extremely fast rise in body temperature during procedures performed under general anesthesia, especially when halogen-containing inhalation agents or succinylcholine (suxamethonium) chloride are employed [1, 2, 4]. It is a very grave disorder that may be fatal, yet presently, the hyperthermia mortality rates do not exceed 10% [1, 2]. Reduced mortality is associated with prompt

administration of sodium dantrolene [5] and putting the patient under intensive care [6]. Previously, the mortality rate in untreated malignant hyperthermia was above 70-80% [7].

The disease may develop following administration of pharmaceutical agents belonging to numerous groups: intravenous anesthetics – ketamine, inhalation anesthetics – halothane, isoflurane, enflurane, fluroxene, desflurane, skeletal muscle relaxants – suxamethonium, dexamethonium, galamine, d-tubocurarine, sympathomimetics, cardiac agents – digitalis glycosides, calcium, as well as in hypercapnia and in individuals under intense stress [1, 2, 3].

Abnormal intracellular distribution of calcium ions is the most important factor in the pathogenesis of malignant hyperthermia. The ions pathologically travel through the calcium channels and enter the sarcoplasm [8], what interferes with the function of intracellular structures. Lactic acidosis rapidly develops, cellular debris such as calcium, phosphorus, potassium, phosphokinase, creatinines and myoglobin enter the circulation and concentration of catecholamines increases [1, 2].

Determining which patients are predisposed to developing hyperthermic reactions is based on medical history taking, clinical assessment and the individual's belonging to a risk group: patients with some diseases involving the musculoskeletal system (myopathy central core disease), congenital myotonic dystrophy and Duchenne muscular dystrophy, familial episodes of malignant hyperthermia, familial unexplained deaths during surgical procedures and anesthesia, fever or dark urine following surgery) [1, 2, 3].

Early symptoms of malignant hyperthermia include muscle rigidity, tachycardia, cyanosis, increased Pet CO₂ (the amount of carbon dioxide present in the exhaled air) and increased sweating. Late symptoms encompass elevated body temperature, hypotension, arrhythmia, metabolic acidosis, electrolyte disturbances, rhabdomyolysis and DIC (disseminated intravascular coagulation [1, 2, 3, 5, 9]). Body temperature is as high as 43-44° C, increasing by 1° C every 5 minutes, yet a temperature rise of approximately 1-2° C per hour is indicative of the disease.

When malignant hyperthermia is suspected, immediate discontinuation of anesthetic agents and succinylcholine is indicated [6, 9], the patient should be ventilated with oxygen and administered sodium dantrolene [10, 11] at the IV dose of 2.5 mg/kg (until symptoms resolve and a total dose of 10mg/kg is reached), antiarrhythmic medications should be introduced (excluding beta channel blockers) and sodium hydrogen carbonate should be given; the patient needs to be physically cooled and his vital functions monitored [1, 2, 5, 6]. Dantrolene is a medication of choice [3, 6, 11], which decreases muscle tone at the same time reverting pathological processes occurring in the muscles in the course of malignant hyperthermia [3]. It is, however, an expensive drug with a relatively short expiry date, thus not all medical centers that offer procedures under general anesthesia have dantrolene at their disposal. In Poland, in consequence of an extremely rare occurrence of the complication, there are no generally accepted standards regulating the availability of the pharmaceutical. In practice it is assumed that an anesthesiologist involved in performing the procedure should know which nearest center has the medication at its disposal to be able to approach such a center with a request for making the drug available. It should be added that for dantrolene to fulfill its role, it needs to be administered maximally within 30 minutes after the patient has developed adverse symptoms.

CASE PRESENTATION

In September 2007, parents reported with their son aged 3 years and 10 months for a scheduled dental procedure to be performed under general

anesthesia. The child presented with numerous caries cavities and deciduous teeth roots requiring extraction. Attempts at dental treatment had been previously undertaken in several dental offices, but they were unsuccessful in view of the patient's negative attitude and his lack of cooperation. One day before the procedure, the patient was consulted and his parents gave their consent to the planned procedure. General medical history was taken and an appropriate questionnaire addressing the child's health was completed by the mother. In view of the collected data, there were no contraindications for general anesthesia. Physical examinations showed right cheek swelling and an antibiotic was prescribed. On the following day, approximately at 9:15 a.m., general anesthesia was induced in the patient, using the following anesthetic medications: Dormicum (midazolami maleas), Sewoflurane, Suxamethonium at the dose of 1mg/kg, oxygen, nitrous oxide and Ketonal (ketoprofenum) as an analgesic; additionally, the boy was administered glucose IV. Teeth 61, 63, 64 and 65 were treated conservatively; teeth 53, 52, 51, 62 and 84 were extracted. During the procedure, after approximately 45 minutes, the patient developed cardiac rhythm disturbances and his temperature rose to 37.4° C. Xylocaine was administered and cardiac rhythm disturbances resolved, but the heart rate was decelerated. Thus, atropine was administered, but the therapeutic effect was maintained for several moments only. Blood oxygen saturation started to decrease, the anesthesiologist observed muscle rigidity in the lower extremities and abnormal positioning of the patient's feet. At that time, the boy's body temperature reached 40° C, he was cooled with cold packs and subsequently, he had a cardiac arrest. The anesthesiologist suspected malicious hyperthermia, an ambulance was called for and resuscitation commenced. Resuscitation was continued by emergency service personnel but proved unsuccessful and at 11:25 a.m. the boy was pronounced dead. A medico-legal postmortem examination and the results of additional tests allowed for determining death as a result of shock, which most likely developed due to malicious hyperthermia.

DISCUSSION

In the presented case, the medical history of the patient as reported by his parents did not provide any grounds for suspecting malignant hyperthermia and did not indicate a need for extended diagnostic management or employing any preventive measures prior to a dental procedure. The evidence (medical records, depositions of witnesses) showed that anesthesia induction, its course and anesthesia itself were uncomplicated until 10:00 a.m., when the boy developed cardiac rhythm disturbances, his body temperature rose and muscle rigidity became apparent. The evidence did not point to the patient presenting with a prodromal sign of malignant hyperthermia, i.e. trismus occurring upon administration of suxamethonium [3, 12]. In case lockjaw develops, intubation of the patient may be proven impossible [14]. The progression of the disease was rapid and complicated by a cardiac arrest, what practically rendered effective treatment impossible.

In the opinion of the experts, the dental procedure was appropriately performed in keeping with the standards. Anesthesiological management with respect to selection of medications and type of anesthesia was also admissible in procedures of this type. Succinylcholine chloride is a pharmaceutical that is increasingly less frequently employed due to its adverse effects, but it has been granted marketing authorization and can be used for medical purposes. Nevertheless, the experts expressed reservations as to the conduct of the female anesthesiologist following the patient's developing complications in the course of anesthesia. Namely, in spite of her suspecting malignant hyperthermia, the physician did not attempt to obtain the pharmaceutical employed in such cases (Dantrolene). An immediate attempt at obtaining the medication and a prompt institution of therapy might have increased the chances of the patient to survive. Abandoning of such an attempt placed the patient at a direct risk of loss of life or severe detriment to health assuming there was a genuine possibility for the medication to be provided before a cardiac arrest, which occurred at 10:30 a.m. Taking into consideration the description of the disease progression, administration of Dantrolene after the cardiac arrest episode did not give a real

chance for saving the life of the child. It should be also taken into consideration that Dantrolene is not a pharmaceutical that would be prophylactically administered to patients outside the malignant hyperthermia risk group, since by itself, it generates adverse effects.

In the course of the investigation it was disclosed that on the day of the child's death, no Dantrolene had been available in the dentist's office where the procedure was performed, but according to the opinion formulated by the national consultant in anesthesiology, a reserve stock of the medication was maintained in two Medical University-affiliated institutions; however, nobody contacted them to obtain the pharmaceutical on the feral day.

The prosecutor's office gave a decision to open an accident death investigation, i.e. investigation of an offence under article 155 of the penal code, in view of the fact that the evidence indicated reasonable suspicion the said offence had been committed. In the course of the investigation, numerous witnesses were heard, extensive medical records were collected and evidence presented in opinions formulated by forensic medicine experts of the Medical University in Lodz was admitted. Ultimately, the prosecutor presented charges against the anesthesiologist for exposing the child to direct danger of loss of life or severe detriment to health, i.e. an offence under article 160 § 3 of the penal code. In January 2011, an indictment act was prepared. In January 2012, the counsel for the defense put forward a motion for convicting to be pronounced without hearing of evidence consisting in conditionally sentencing the female offender to a ten-month jail term suspended to allow her to perform a 2-year period of probation. The defendant confirmed the position of the counsel for the defense and the prosecutor, the legal counsel to the subsidiary prosecutors and the subsidiary prosecutors themselves (the parents of the deceased boy) did not file an objection. The defendant admitted making a mistake during anesthesia procedure performed in the child, in consequence of which the boy died: in view of the patient developing symptoms typical for malignant hyperthermia in the course of the procedure, in spite of suspicion being raised of the patient suffering from the very disease, acting unintentionally, she did not make an attempt

at obtaining sodium dantrolene. She was acknowledged guilty of the act as charged, i.e. of an offence under article 160 § 3 of the penal code and sentenced to 10 months' imprisonment suspended for a 2-year probation period. The court took into consideration the personal characteristics of the

accused, her earlier life and course of professional career as well as the fact that she very emotionally took the events in question and immediately afterwards abandoned her medical practice. Following the pronouncement of the sentence, the accused apologized to the subsidiary prosecutors.

REFERENCES

1. Stowell K. M.: Malignant hyperthermia: a pharmacogenetic disorder, *Pharmacogenomics*, 2008, 9: 1657-1672.
2. Gurnaney H., Brown A., Litman R. S.: Malignant hyperthermia and muscular dystrophies, *Anesth. Analg.*, 2009, 109: 1043-1048.
3. Mayzner-Zawadzka E.: Śródoperacyjna hipertermia złośliwa – etiopatogeneza i wybrane zagadnienia kliniczne, *Anest. Inten. Ter.*, 1993, 1-2: 39-43.
4. Bujok G., Staudt-Spychałowicz G., Sitek J.: Nietypowy zespół hipertermiczny u dziecka po anestezji, *Anest. Inten. Ter.*, 1992, 24: 37-39.
5. Hutton D.: Emergency preparedness case study: malignant hyperthermia, *Plast. Surg. Nurs.*, 2012, 32: 80-83.
6. Mayzner-Zawadzka E., Sowiński P.: Postępowanie anestezjologiczne w zagrażającym zespole hipertermii złośliwej, *Anest. Inten. Ter.*, 1991, 23: 314-317.
7. Kim D. C.: Malignant hyperthermia, *Korean J Anesthesiol.*, 2012, 63: 391-401.
8. Correia A. C., Silva P. C., da Silva B. A.: Malignant hyperthermia: clinical and molecular aspects, *Rev. Bras. Anesthesiol.*, 2012, 62: 820-837.
9. Rybicki Z.: Gorączka złośliwa, *Intensywna terapia dorosłych*, Makmed, Lublin 2009, 192-194.
10. Musselman M. E., Saely S.: Diagnosis and treatment of drug-induced hyperthermia, *Am. J. Health Syst. Pharm.*, 2013, 1: 34-42.
11. Flewellen E. H. i in.: Odpowiedź na podawane dawki dantrolenu u przytomnego człowieka, przesłanki odnośnie postępowania w hipertermii złośliwej, *Anest. Inten. Ter.*, 1985, 1: 79.
12. Gronert G. A. i in.: Złośliwa gorączka wywołana u świń, rola mięśni szkieletowych we wzroście zużycia tlenu, *Anest. Reanim. Inten. Ter.*, 1977, 3: 362.
13. Michalewski W., Szczepański J., Sachajdak-Michalewska Z.: Gorączka złośliwa (Malignant hyperthermia) – podstępne zjawisko okołoperacyjne – ocena sądowo-lekarska po operacji cięcia cesarskiego, *Arch. Med. Sąd. Kryminol.*, 1998, 3-4: 227-232.

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Niecodzienny przypadek samobójczego zatrucia tlenkiem węgla przy użyciu przenośnego grilla ogrodowego*

An unusual case of suicidal carbon monoxide poisoning committed using a portable barbecue grill

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Śmiertelne zatrucia tlenkiem węgla są dość często spotykane w praktyce medycyно-sądowej. Choć zazwyczaj mamy wówczas do czynienia ze zdarzeniami o charakterze nieszczęśliwego wypadku, to przypadki zatruc samobójczych też nie należą do rzadkości – tak w Polsce, jak również w innych krajach europejskich. Źródłem trującego gazu, mającego posłużyć samobójcy do odebrania sobie życia, bywają zazwyczaj spaliny silników samochodowych i domowych piecyków gazowych w instalacjach podgrzewających wodę uwalniane w zamkniętych pomieszczeniach. W niniejszej pracy pragniemy przedstawić nietypowy przypadek, jedynie w historii krakowskiego Zakładu, w którym do uzyskania wysokiego stężenia tlenku węgla wykorzystano palące się brykiety węglowe w typowym, przenośnym grillu ogrodowym. Liczący 65 lat mężczyzna rozpałił go w zamkniętym od wewnątrz pokoju, gdzie wcześniej uszczelnił wszystkie szpary i otwory wentylacyjne, a przy wejściu zostawił kartkę ostrzegającą współmieszkańców o obecności gazu. Ustalenia śledcze wskazały, że podłożem targnięcia się na własne życie były przede wszystkim kłopoty zdrowotne. Z analizy piśmiennictwa wynika, że taki sposób samobójstwa (mimo dużej dostępności materiałów) należy do wyjątkowej rzadkości w kulturze europejskiej czy amerykańskiej, gdzie literatura przynosi opisy tylko pojedynczych przypadków. Natomiast zwrócono uwagę, iż wykorzystywanie grillów do samobójczych zatruc stało się w ostatnich kilkunastu latach niezwykle powszechne w krajach Dalekiego Wschodu. Wskaza-

no pewne historyczno-kulturowe uwarunkowania mogące mieć wpływ na tak wyraźną geograficzną polaryzację występowania omawianej metody w niektórych państwach azjatyckich oraz przytoczono dyskutowaną w piśmiennictwie naukowym znaczącą rolę mediów w popularyzacji takiego sposobu samobójstwa.

Fatal carbon monoxide poisoning is relatively often encountered in medico-legal practice. Although we usually deal with events of an accidental nature, cases of suicidal character are also quite common, both in Poland and in other European countries. The source of a poisonous gas that is used by a suicide to take his life are usually exhaust fumes from cars and home gas water-heaters that are released in closed spaces. In the present report, the authors present an atypical case – the only such instance in the history of the Krakow Department – where a high carbon monoxide concentration level was achieved by burning briquetted coal in a typical portable barbecue grill. A 65-year old male lit the grill in a room locked from inside, where he had previously sealed all cracks and vents; he left a written message by the entrance where he warned his flatmates about the presence of gas. The investigation determined that the predominant underlying reason of his committing suicide were health problems. As it follows from the analysis of literature on the subject, despite extensively available materials, such a suicide method is exceptionally rare in the European or American culture,

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