

LETHAL ACCIDENTS IN STORAGE EQUIPMENT: A REPORT OF TWO CASES

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Abstract: The paper analyses the causes and mechanisms of death, the possibilities of providing effective emergency assistance, and the regulations for work safety on the basis of two lethal accidents at work in storage equipment. The death mechanism, i.e. asphyxia due to respiratory tract obstruction by a loose foreign substance prevents effective emergency assistance unless aspiration has not yet occurred. The deciding factor is how soon the rescue procedure begins. The safety-at-work regulations should emphasize the need for worker protection by the assistance of another person.

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INTRODUCTION

Accidents at work in agriculture are usually associated with incorrect use of mechanical devices and animal related injuries. They result in injuries in the form of e.g. wounds, bone fractures or death. Such cases have been fairly well understood by researchers examining accidents in agriculture and their health consequences [4, 9, 13, 16, 18, 19, 20, 22]. Research in this field has yielded statistical data on the frequency of such incidents and resulted in the development of safety procedures and the principles of first aid. The obtained data show that there are relatively few accidents at work inside grain storage equipment.

CASES DESCRIPTION

Case 1. During the harvest there was a fatal accident which concerned a 5-year-old male child. It was determined that the accident had occurred at a farm when the child was playing on a cereal pile. The pile was about 2.5 m high with the base diameter of about 15 m. There was a screw feeder on the pile base, which transported the grain to the drying room. This resulted in the formation of a crater at the top of the pile, with the diameter of approx. 2 m into which the playing child fell. After a few minutes, the child was

completely covered with grain. The attempted resuscitation failed and the child died. During resuscitation, a large amount of grain was removed from the respiratory tract, and also from the oral cavity and the pharynx. The autopsy revealed a large amount of grain and dust in the oral cavity and the respiratory tract, from the thorax down to the lobar bronchus. It was concluded that the cause of the child's death was sudden suffocation caused by obstruction of the respiratory tract with a foreign body, with possible concurrent crushing of the thorax.

Case 2. A 52-year-old farmer climbed from the base of a 10-meter tower silo which contained bran pulp. The man lifted the lid and while looking inside he fell into the silo. The employees who witnessed the incident went to the rescue. The problem was how to pull the sinking man out of the loose, low-density material. At the time, the silo was filled to $\frac{3}{4}$ of its capacity. The rescuers managed to pull the man out after approx. 10 minutes. He was unconscious and had respiratory and cardiac arrest. The rescuers attempted to resuscitate the man and their efforts were continued by an ER team. Intubation was preceded by the removal of a significant amount of bran pulp from the oral cavity and the pharynx. However, the resuscitation failed and the patient was pronounced dead. The autopsy revealed a significant



amount of bran pulp in the oral cavity and the respiratory tract, from the pharynx down to the lobar bronchus. The bran pulp swelled under the effect of saliva and mucus and completely blocked the lumen of the respiratory tract. It was concluded that death was caused by obstruction of the respiratory tract with a foreign substance. Blood and urine analysis using gas chromatography showed the presence of 0.7‰ ethyl alcohol in the blood and 0.8‰ ethyl alcohol in the urine.

DISCUSSION

The statistical data obtained on the basis of autopsies carried out at the Department of Forensic Medicine in Wrocław confirm that fatal accidents at work in agriculture involving asphyxia due to aspiration of foreign substances are extremely rare. In the years 1997-2007, there were 9,160 autopsies, of which just 34 cases (0.37%) concerned accidents at work in agriculture. Of this group, only the two above-mentioned cases had the mechanism of death caused by aspiration of a foreign body and asphyxia. The most common accidents involved mechanical injuries caused by technical devices or during field-work. Such observations correspond with the data obtained from other studies, although it should be noted that in many statistical analyses lethal asphyxia due to aspiration of a foreign substance was not listed as a separate group of incidents [4, 5, 14, 15, 21]. A similar category with respect to the causes and circumstances of death concerns flowing grain entrapments in grain transport vehicles [10]. Detailed American and Canadian studies of fatal entrapments in on-farm grain storage bins [11, 12] help us to identify the causes of such accidents. They not only provide statistical data, but also allow us to isolate and analyse the risk factors. Such observations provide the basis for accident prevention by means of educational materials and recommendations for engineering controls. One valuable conclusion is that most original causes of accidents are preventable if correctly functioning preventive measures are in place.

There are two important aspects here from the point of view of agricultural medicine. Firstly, we should analyse the pathophysiological mechanism leading in such cases to death and assess the possibilities of providing an effective emergency procedure. Secondly, we should determine the causes of the accidents and appraise the existing occupational safety principles.

The discussed cases can be classified as lethal asphyxia due to obstruction of the respiratory tract. In the presented cases, an additional factor important for the assessment of the death mechanism could be the immobilization of the thorax that prevented or restricted respiratory movements. Both those factors result from the properties of the materials stored in silos. As a rule, the stored material is loose, fine grained, consists of numerous small particles, and has a low density. This causes easy submersion of a human body into a pile and easy aspiration of foreign matter into

the respiratory tract. The stages of the process resemble the drowning of a man in water. The initial stage is characterised by self-defence, holding of breath, and typically violent movements to stay on the surface. In such a case, the result is quicker submersion into the pile caused by pushing away the material that supports the body. Next, there is a period of prominent respiratory movements caused by increasing breathlessness, accompanied by aspiration of foreign matter and loss of consciousness due to respiratory failure [3]. Under conditions occurring in closed spaces used for feedstuff and grain storage there is another significant factor contributing to the asphyxia of a victim, namely, the restriction of respiratory movements caused by immobilization of the thorax due to pressure exerted by the stored material. An important factor in the pathomechanism of death is the cough reflex. Paradoxically, its occurrence only makes things worse [6] because the reflex is only effective if the respiratory tract is an air free passage. During the first stage of the reflex, a person violently inhales into the lungs 2-2.5 litres of air, then the epiglottis closes and the contraction of the expiratory muscles ejects air together with the foreign body present in the respiratory tract. However, if a large amount of loose material is present in the respiratory tract (as in the case of grain or feedstuff), during the inhalation stage of the reflex, there is an additional aspiration of a large amount of foreign matter which usually leads to total obstruction of the respiratory tract. Consequently, the subsequent stage of the cough reflex (exhalation) is ineffective. Another detrimental factor that can sometimes occur is oedema of the mucous membrane of the respiratory tract (mainly the larynx) and accompanying increased production of mucus. In such a case, the aspirated matter changes into a dense, pulpy mass. In both cases, examination revealed laryngeal oedema and a “stopper” made of foreign matter that completely obstructed the respiratory tract lumen.

The ability to save the victim of a fall into a silo depends mostly on the speed of the rescue operation. It is estimated that such victims sink into grain in a matter of seconds [17]. Once a significant amount of foreign matter has been aspired, there are practically no means to effectively unblock the respiratory tract, whether manually or by intubation, due to the above-mentioned properties of the aspired substance. In both cases discussed here the rescue efforts included attempted restoration of the respiratory activity. The doctors taking part in the resuscitation reported that they had been unable to clear the respiratory tract and carry out effective ventilation. Post-mortem observations proved that in fact only a small amount of foreign matter was removed – the main obstacle to breathing was still present in the larynx and the trachea, and due to its location and consistency it prevented effective intervention of the rescuers. Even during the autopsy the removal from the respiratory tract of such bran-and-grain “stopper” was difficult and time consuming. The inability to carry out an effective emergency rescue (apart from cases where

aspiration has not yet occurred) makes such cases particularly dangerous.

A number of analyses draw attention to the fact that the main causes of accidents at work are incorrect work organisation and disregard for safety regulations [1, 15]. One of the main factors increasing the risk of an accident is, without doubt, the intoxication of the victims. In the statistical assessment of fatal accidents at work, the state of intoxication was most frequent in the case of victims of falls from heights [1, 21]. Such observations correlate with the discussed cases.

It is worth looking at the existing Polish regulations and guidelines on rules of work near grain and grain product storage equipment. These are: the ordinance of the Minister of Agriculture and Food Economy on health and safety at work while operating tractors, farm machinery, tools, and technical devices used in agriculture [24]; the ordinance of the Minister of Labour and Social Policy on the types of work that should be performed by at least two people [25]; and the ordinance of the Minister of Agriculture and Food Economy on health and safety at work during the grain processing and production of plant-based feedstuff [26]. The current ordinances are executive acts to the Labour Code. The content of the regulations demonstrates a keen awareness of the existing threats, both on the part of the legislator and the circles involved in health and safety at work in agriculture. Among others, the legislator emphasizes that all works inside a silo have to be carried out in the presence at least two persons (the obligatory protection measure), fire safety must be maintained (risk of dust explosion), and the appropriate room ventilation must be maintained (access of fresh air). Such legislative measures, which provide the guidelines for the creation of health and safety-at-work regulations, seem to be sufficient, although it would be best to expand the list of works requiring protection by another person to include all kinds of activities where there is a risk of a fall into a pile of stored loose material. Such standards are in accordance with the guidelines of the European Union and resemble the standards in place in other countries of the European Community. Many agricultural safety and health standards effective in the US can be found in the databases of the United States Department of Labor, the Occupational Safety and Health Administration (OSHA), and the National Agricultural Safety Database (NASD) [17,27]. They include the safety procedures for confined spaces, covering storage, transport, and unloading of grain or similar products. Apart from typical hazards posed by machinery and fire, special attention is given to the risk of suffocation due to lack of oxygen inside a bin or burial or sinking in grain. Preventive measures are understood as assistance by another person, use of safety harnesses, prohibition of entry into a grain bin when grain is being removed, installation of ladders inside and outside all bins, and use of respiration protection devices (dust filter masks and filter respirators).

CONCLUSIONS

Accidents at work inside grain storing equipment are rare, but are extremely life threatening. The mechanism of death prevents the possibility of effective help unless the rescue efforts start immediately. The key factor determining if a victim can be saved is the moment of aspiration of loose matter into the respiratory tract lumen. The formation of a foreign-matter "stopper" practically gives no possibility of clearing the respiratory tract and providing effective ventilation.

The causes of such accidents are typical: disregard for safety regulations and alcohol abuse. Legal regulations emphasize obligatory assistance by another person during work inside silos. Such precaution is essential for quick reaction in an emergency. However, we should also consider the extension of this obligatory protection to all works where there is a risk of sinking into a pile of loose material.

REFERENCES

1. Ames GM, Grube JW, Moore RS: Social control and workplace drinking norms: A comparison of two organizational cultures. *J Stud Alcohol* 2000, **61**, 203-219.
2. Baker DE: Safe storage and handling of grain. GO1969, October 1993. *NASD Rev* 04/2002. Available from: <http://www.cdc.gov/nasd/docs/d000801-d000900/d000883/d000883.pdf>.
3. Brinkmann B, Püschel K, Bause HW, Doehn M: Death by obstructive asphyxia: the pathophysiology of respiration and hemodynamics. *Z Rechtsmed* 1981, **87**, 103-116.
4. Browning SR, Truszczynska H, Reed D, McKnight RH: Agricultural injuries among older Kentucky farmers: The farm family health and hazard surveillance study. *Am J Ind Med* 1998, **33**, 341-353.
5. Cyr DL, Johnson SB: Grain Storage Safety. *NASD Rev* 09/2006. Available from: <http://www.cdc.gov/nasd/docs/d000901-d001000/d000906/d000906.html>.
6. Cież J: Accident risk among private farmers related to using of farm machinery. *J Res Appl Agric Eng* 2005, **50**, 41-44. Available from: http://www.pimr.poznan.pl/biul/2005_1_9C.pdf (in Polish).
7. Cież J: Struktura i następstwa wypadków przy pracy w rolnictwie indywidualnym woj. wrocławskiego. In: Zagórski J (Eds): *Wypadkowość w Rolnictwie*, 67-75. Lublin 1996.
8. DiMaio VJ, DiMaio D: *Medycyna sądowa*, Urban Partner, Wrocław 2003.
9. Franklin RC, Mitchell RJ, Driscoll TR, Fragar LJ: Agricultural work related fatalities in Australia 1989-1992. *J Agric Saf Health* 2001, **7** (4), 213-227.
10. Kelley KW, Field WE: Characteristics of flowing grain-related entrapments and suffocations with emphasis on grain transport vehicles. *J Agric Saf Health* 1996, **2**(3), 143-156.
11. Kingman DM, Field WE: Using fault tree analysis to identify contributing factors to engulfment in flowing grain in on-farm grain bins. *J Agric Saf Health* 2005, **11**(4), 395-405.
12. Kingman DM, Field WE, Maier DE: Summary of fatal entrapments in on-farm grain storage bins. *J Agric Saf Health* 2001, **7**(3), 169-184.
13. Lewandowski B, Szymańska J: Agriculture-related severe craniofacial injuries in rural children and adolescents. *Ann Agric Environ Med* 2008, **15**, 59-62.
14. McCurdy SA, Carroll DJ: Agricultural injury. *Am J Ind Med* 2000, **38**, 463-480.
15. Monitoring of the labour market, accidents at work 2007. GUS. Available from: <http://www.stat.gov.pl>.



16. Myers JR: *Injures Among Farm Workers in the United States 1994*. Washington DC. National Institute for Occupational Safety and Health; 1998 DHHS (NIOSH) publication 98-1953.
17. National Agricultural Safety Database (NASD). Available from: <http://www.cdc.gov/nasd>.
18. Nogalski A, Jankiewicz L, Ćwik G, Karski J, Matuszewski Ł: Animal related injuries treated at the department of trauma and emergency medicine, Medical University of Lublin. *Ann Agric Environ Med* 2007, **14**, 57-61.
19. Nogalski A, Lúbek T, Sompór J, Karski J: Agriculture and forestry work-related injuries among farmers admitted to an emergency department. *Ann Agric Environ Med* 2007, **14**, 253-258.
20. Rissanen P, Taattola K: Fatal injuries in Finnish agriculture 1988-2000. *J Agric Saf Health* 2003, **9(4)**, 313-326.
21. Rygół K, Kabiesz-Neniczka St, Olszówy Z: Accidents in the workplace caused by alcohol intoxication. *Arch Med Sqd Krym* 2004, **54**, 234-241. Available from: http://www.amsik.pl/archiwum/4_2004/4_04h.pdf (in Polish).
22. Stallones L: Surveillance of fatal and non-fatal farm injuries in Kentucky. *Am J Ind Med* 1990, **18**, 223-234.
23. *The Report of the Chief Labour Inspector for 2007*. GIP. Available from: <http://www.pip.gov.pl>.
24. The ordinance of the Minister of Agriculture and Food Economy of 12 January 1998 on health and safety at work while operating tractors, machinery, tools, and technical devices used in agriculture. *Pol J Law* 1998, **12**, 51 (in Polish).
25. The ordinance of the Minister of Labour and Social Policy of 28 May 1996 on the types of work that should be performed by at least two people. *Pol J Law* 1996, **62**, 288 (in Polish).
26. The ordinance of the Minister of Agriculture and Food Economy of 24 January 1996 on health and safety at work during the grain processing and production of plant-based feedstuff. *Pol J Law* 1996, **14**, 78 (in Polish).
27. United States Department of Labor, Occupational Safety and Administration (OSHA), Standard No. 1910.272.

