

Survived ileocecal blowout from compressed air

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Abstract Industrial accidents with compressed air entering the gastro-intestinal tract often run fatally. The pressures usually over-exceed those used by medical applications such as colonoscopy and lead to vast injuries of the intestines with high mortality. The case described in this report is of a 26-year-old man who was harmed by compressed air that entered through the anus. He survived because of fast emergency operation. This case underlines necessity of explicit instruction considering hazards handling compressed air devices to maintain safety at work. Further, our observations support the hypothesis that the mucosa is the most elastic layer of the intestine wall.

Keywords Pneumatic rupture · Colon · Compressed air · Bowel perforation · Intestinal injury · Traumatic colon perforation

Introduction

The use of compressed air has become common in many workplaces. Injuries associated with the use or misuse of compressed air is less frequently encountered. Compressed air injuries often reveal a misguided co-worker and unwise

behaviour. Those cases not involving misbehaviour usually occurred when employees used a compressed air device to dust off their clothing. Among pneumatic injuries, colon injury by insufflations with compressed air is one of the most serious injuries. Although the air pressure can vary in different situations, it was suggested that it takes only 1 or 2 s to deliver enough compressed air to cause major damage [1, 2]. When severe pneumatic injuries of the colon occur, prompt medical intervention is critical for life saving.

Case report

A 26-year-old man was working in a foundry bent forward to check a casting mould for defects. A teammate approached from behind with a compressed air cleaner in his hand. He released the nozzle in a fraction of a second just near the anus of the unsuspecting man. Immediately, the victim felt the strongest pain in the belly and was delivered into the emergency department. Signs of an acute abdomen with peritoneal irritation, meteorism, difficulty in breathing and an abdominal compartment syndrome were ascertained. Computer tomography scanning showed free air in the peritoneal cavity and massively ballooned intestine (Fig. 1). The victim underwent emergency surgery.

Surgeon's findings and treatment

The exploration of the peritoneal cavity showed a disastrous condition: malodorous and bloody exudates, balloon-like distensions of the distal part of the ileum and the ascending, transversal and descending colon with blue discolourations and petechiae in the serosa. The serosa was partly torn. The colon had to be sub-totally resected. The uncommonly long sigma (approximately 60 cm) was connected with the terminal end of the ileum. A temporary

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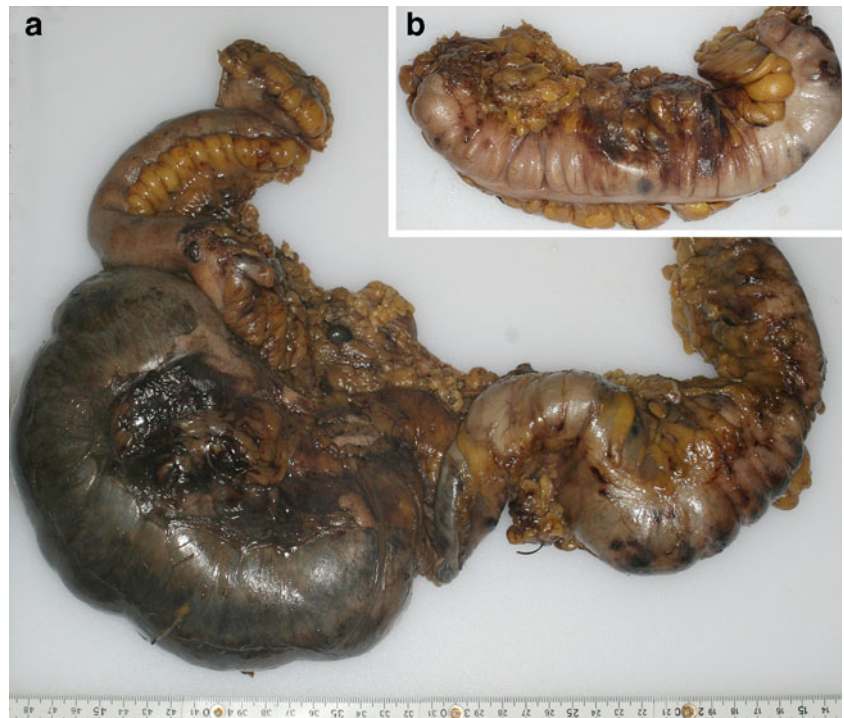
Fig. 1 Computed tomography (CT) scan taken on the day of hospitalisation about 1 h after the accident. Note the massive dilation of the colon (*arrows*) and subphrenic accumulation of air between liver and diaphragm (*arrowheads*). Contrast medium was administered prior CT scanning

double-barrel ileostomy was joined with the abdominal wall.

Forensic medical examiner's findings

One day after the trauma, the victim was examined for putative outer injuries that could be indicative of a preceding assault. The man was of normal build, length 1.90 m, weight 95 kg. Beside signs of medical treatment, no further injuries could be detected.

Fig. 2 The two resected colon parts after fixation in formaldehyde. **a** Terminal ileum, caecum and ascending colon. **b** Part of the transversal colon. The caecum is massively distended, and the wall is discoloured, whereas terminal ileum, ascending and transversal colon show haemorrhages to a lesser extent



Preparation of the resected intestine

The two resected intestine parts were fixed in 5% formaldehyde. They were dissected after 3 days of fixation.

The first specimen was 43 cm long and consisted of the proximal part of the colon (22 cm) including caecum, appendix and ascending colon, as well as the distal part of the ileum (21 cm). The appearance of the appendix was normal. The caecum and the distal part of the ascending colon were strongly distended with a circumference of 22 cm and were covered with haemorrhages (Fig. 2a). Apparently, the intestinal wall was thinned out, whereas a full penetration of the wall was not observed, but the serosa was disrupted and gaped until 10 cm in diameter. Furthermore, there were spotty haemorrhages in the mesenteries of the colon and the ileum. The terminal ileum was only slightly affected with few haemorrhages and little distension. The ileum was filled with normal content, whereas in the colon, the faeces were of pulpy consistency and mixed with blood.

The second specimen was identified as transversal colon measuring 27 cm in length (Fig. 2b). The intestine presented roundish haemorrhages into the intestinal wall. A 1.2-cm measuring serosa tear with surrounding haemorrhage was detected on the surface near the taenia libera. However, the intestinal wall was also not completely penetrated. In this specimen, normal but loosened faeces were found.

Specimens were obtained from all areas and prepared for histological examination.

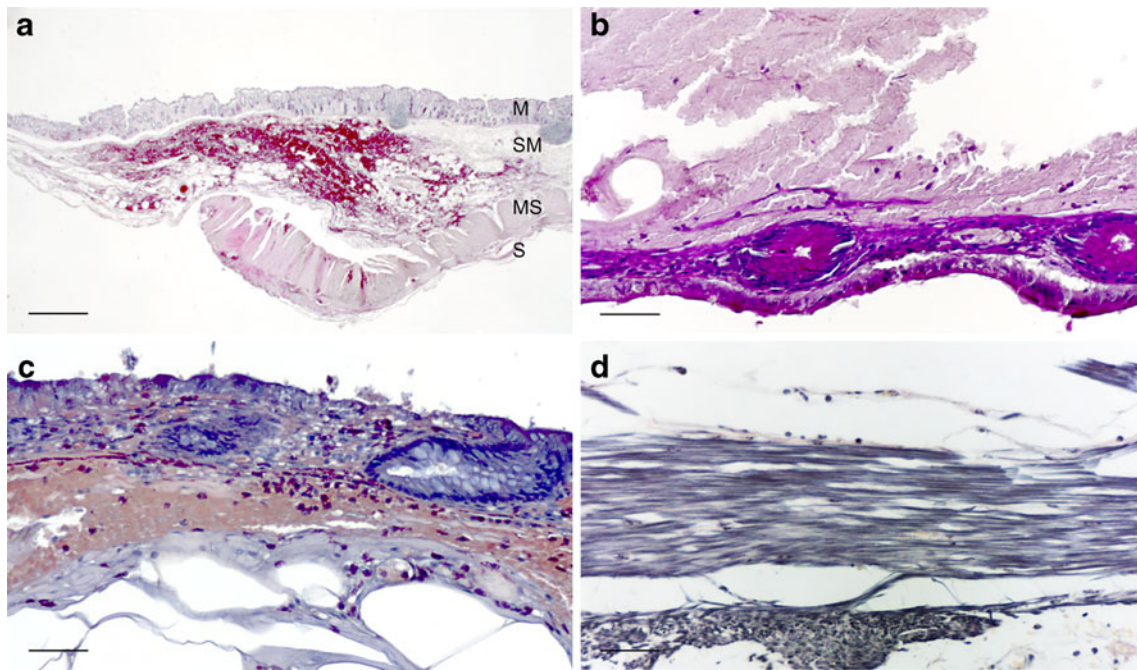


Fig. 3 Histological examination revealed no through-and-through penetration of the intestinal wall. **a** Haematoxylin and eosin staining. Stretched mucosa (*M*) and disrupted serosa (*S*) as well as muscularis (*MS*) in the caecum and widened submucosa (*SM*) with haemorrhage; scale bar 1 mm. **b** Periodic acid-Schiff staining. In another part of the caecum, flattened mucosa and remains of the basal lamina (*lower part*). The cloudy material up the basal lamina is blood; scale bar, 50 μ m. **c** Chloroacetate esterase staining. Note the granule cells

(*carmine colour*) within a small capillary and migrating into the injured zone in the submucosa and the mucosa; scale bar, 50 μ m. **d** Phosphotungstic acid-haematoxylin staining. The smooth muscle in the muscularis was found stretched and torn in the same intestine part (caecum) as in Fig. 2c; scale bar, 50 μ m. All micrographs were taken by means of a microscopic camera and Axiovision software (Zeiss, Jena, Germany)

Histologic examination

The specimens were stained following [3] with haematoxylin and eosin, periodic acid-Schiff, naphthol AS-D chloroacetate esterase and phosphotungstic acid-haematoxylin. Some parts of the intestine were unaffected, whereas others showed massive haemorrhages into the intestinal wall. The serosa and muscularis were completely disrupted, whereas the mucosa was in a quite good condition (Fig. 3a, d). Interestingly, in the injured parts of the caecum, the mucosa appeared dramatically stretched and flattened (Fig. 3b, c). In some location, just the basal lamina and remains of the muscularis warranted integrity of the wall (Fig. 3b). Granule cells migrating from blood vessels towards the haemorrhage indicate the beginning inflammation (Fig. 3c). In the terminal ileum, the wall layers were not affected. Here, the wall was moderately stretched, and the veins were stuffed with blood (not shown). In all parts of the intestine, no signs of pre-existing pathology or trauma could be detected [4].

The compressed air device

The device that was used is a spray head driven by a compressed air motor. The spray head is made of aluminium with a barrel of 20 cm length and a bore of

12 mm (Silvent, Borås, Sweden, Fig. 4). The head is connected to a stationary air pressure system. The gas used was air. The operating pressure of the system is specified with 6 to 7 bar according to about 4,500 to 5,250 mmHg. This pressure is warranted by automatic control. The actual pressure at the end of the bore depends on the power when operating the trigger. If the trigger is not fully opened, the release pressure will be at a lower level as compared to the given operating pressure. All parts of the pressure system were checked for technical defects. The system was functioning properly. As proved by the documentation about maintenance of industrial health and safety standards,



Fig. 4 The nozzle of the compressed air cleaner has a diameter of about 12 mm and is connected to a stationary air pressure system via flexible hose

all workers were in particular instructed not to point the spray head towards parts of the body.

Patient's outcome

The temporary double-barrel ileostomy was reversed 2 months after the ileodiscendostomy proved to be sufficient. More than 1.5 years after the assault, the young man still suffers from intestinal symptoms. Urge incontinence with diarrhoea up to nine times a day independently from the composition of the nutrition is caused by the shortened intestinal passage. Sudden pricking scar pain still occurs when carrying heavy loads. Therefore, the victim suspended sporting activities and is restricted in his job.

The public prosecutor brought a charge of grievous bodily harm against the delinquent. The perpetrator was sentenced to 6 months prison suspended on probation.

Discussion

About 150 cases of colon rupture by compressed air have been described so far (for reviews, see [5, 6]). The first report dates back to 1904 [7]. The overall mortality of pneumatic rupture of the bowel was assessed at 65%. If the acute shock was not immediately fatal, the survival was depending from further treatment. Surgery reduced mortality to 42% [6]. According to [8], the pathophysiology of death can be (a) acute air embolism, (b) acute fat embolism, (c) acute respiratory insufficiency due to enhanced intra-abdominal pressure and chest compression, (d) acute heart failure due to insufficient preload and (e) peritoneal shock. Recovery is usual if only the serous and muscular coats are torn [6]. However, in such cases of incomplete rupture, the mucosa might prolapse, and delayed complete rupture can occur [9, 10]. The vast majority of perforations reported are in the region of the rectosigmoid and the sigmoid colon. Caecal barotrauma is commonly caused by colonoscope air flow and pressure [11].

Here, we present the unusual case of a young man who survived transanal compressed air supply due to fast admission to a hospital and emergency operation. Forensic examination revealed no collateral superficial bruises or scratches indicating that there was no fray prior to the assault, which is in agreement with witnesses' statements.

Interestingly, not all parts of the surgically resected large intestine were affected by the compressed air although the air entered through the anus. In particular, the sigmoid colon as well as the rectum showed no signs of injury. Furthermore, the terminal ileum was only slightly distended and showed some haemorrhage, but to a much lesser extent than the nearby caecum. This might be due to an unimpaired flow of the compressed air through the downstream parts of the colon. The highly flexible sigmoid colon might have been a

prerequisite for easy passing of the air through this part. However, the air must have accumulated to maximum pressure in the caecum most probably due to a closed ileocecal valve exerting its traumatic effects predominantly in the caecum and the ascending colon.

Moreover, the bowel perforation was incomplete because the mucosa was not torn up. In agreement with previous work, our observations support the hypothesis that the mucosa is the most elastic layer of the intestine wall, whereas the serosa and the muscularis are the least [5, 8]. Further, it was stated that pressures above 4.07 psi (according to 210.48 mmHg) are necessary to cause a through-and-through rupture of the intestinal wall. Colonoscopic insufflation of isolated cadaver colon was associated with transmural perforation at pressures of 120 mmHg in the caecum and 202 mmHg in the sigmoid colon [12]. Thus, in the presented case with operation pressures above 4,500 mmHg, a complete intestinal perforation should have to be expected. However, one can assume that the drop in pressure along the way through the distal parts of the colon must have been vast, as we did not observe a transmural perforation. Additionally, the findings support the idea that the spray head valve was not completely opened and that the device was not placed directly on the anus resulting in much lower pressure entering the colon. Further, worn clothing and the anal sphincters might have weakened the pressure and the volume of the applied air. We could find only one more comparable report [13] where the victim recovered 6 weeks after surgery, but technical data of the air pressure system used were not available.

It is important to realise that severe injury or death can occur without inserting the air nozzle into the anus. The sporadic appearance of such fatalities has not made compressed air a significant issue in the industrial or commercial setting.

References

1. Zunzunegui RG, Werner AM, Gamblin TC, Stephens JL, Ashley DW (2002) Colorectal blowout from compressed air: case report. *J Trauma* 52:793–795
2. Kim SJ, Ahn SI, Hong KC, Kim JS, Shin SH, Woo ZH (2000) Pneumatic colonic rupture accompanied by tension pneumoperitoneum. *Yonsei Med J* 41:533–535
3. Tsokos M, Herbst H (2005) Black oesophagus: a rare disorder with potentially fatal outcome. A forensic pathological approach based on five autopsy cases. *Int J Legal Med* 119:146–152
4. Byard RW, Heath K (2010) Mesenteric fibrosis—a histologic marker of previous blunt abdominal trauma in early childhood. *Int J Legal Med* 124:71–73
5. Raina S, Machiedo GW (1980) Multiple perforations of colon after compressed air injury. *Arch Surg* 115:660–661
6. Brown RK, Dwinelle JH (1942) Rupture of the colon by compressed air: report of three cases. *Ann Surg* 115:13–20
7. Stone GW (1904) Rupture of the bowel caused by compressed air. *Lancet* 2:216–218

8. Althoff H (1969) Plötzlicher Tod nach einer Exposition mit Druckluft. *Monatsschr Unfallheilkd Versicher Versorg Verkehrsmed* 72:501–506
9. Lau AF (1967) Beitrag zur perforation des Dickdarms verursacht durch Druckluft. *Zentralbl Chir* 92:2701–2703
10. Marwah S, Gupta R, Singh I, Marwah N (2002) Compressed air injury of the colon—delayed presentation. *Indian J Gastroenterol* 21:206–207
11. Woltjen JA (2005) A retrospective analysis of cecal barotrauma caused by colonoscope air flow and pressure. *Gastrointest Endosc* 61:37–45
12. Kozarek RA, Sanowski RA (1980) Use of pressure release valve to prevent colonic injury during colonoscopy. *Gastrointest Endosc* 26:139–142
13. Onyedunma EC, Akande B, Adedeji SA (1987) Compressed air injury of the colon, a case report. *Trop Geogr Med* 39:303–305