

# The Legend of the Buffalo Chest



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**BACKGROUND:** The “buffalo chest” is a condition in which a simultaneous bilateral pneumothorax occurs due to a communication of both pleural cavities caused by an iatrogenic or idiopathic fenestration of the mediastinum. This rare condition is known by many clinicians because of a particular anecdote which stated that Native Americans could kill a North American bison with a single arrow in the chest by creating a simultaneous bilateral pneumothorax, due to the animal’s peculiar anatomy in which there is one contiguous pleural space due to an incomplete mediastinum.

**RESEARCH QUESTION:** What evidence is there for the existence of buffalo chest?

**STUDY DESIGN AND METHODS:** The term “buffalo chest” and its anecdote were first mentioned in a “personal communication” by a veterinarian in the *Annals of Surgery* in 1984. A mixed method research was performed on buffalo chest and its etiology. A total of 47 cases of buffalo chest were identified in humans.

**RESULTS:** This study found that all authors were referring to the article from 1984 or to each other. Evidence was found for interpleural communications in other mammal species, but no literature on the anatomy of the mediastinum of the bison was found. The main reason for this research was fact-checking the origin of the anecdote and search for evidence for the existence of buffalo chest. Autopsies were performed on eight bison, and four indeed were found to have had interpleural communications.

**INTERPRETATION:** We hypothesize that humans can also have interpleural fenestrations, which can be diagnosed when a pneumothorax occurs. CHEST 2021; 160(6):2275-2282

**KEY WORDS:** buffalo chest; pleural diseases; pneumothorax

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## Take-home Points

**Study Question:** Is the “buffalo chest” an existing entity in North American bison?

**Results:** In autopsies on eight bison, four of the animals were found to have interpleural communications.

**Interpretation:** Because humans share many similarities with other mammals in embryologic development, it is important to always examine the contralateral chest when a patient presents with a pneumothorax as a bilateral pneumothorax that is overlooked can be fatal because of the risk of a bilateral tension pneumothorax.

In February 2018, *The New England Journal of Medicine* published a review article entitled “Pleural disease” by David Feller-Kopman and Richard W. Light.<sup>1</sup> As residents in pulmonology, we read this article during our Journal Club and were intrigued by a particular clinical condition that was mentioned in the article: the buffalo chest. Buffalo chest is a potentially life-threatening condition in which a simultaneous bilateral pneumothorax occurs due to a communication of both pleural cavities caused by iatrogenic or idiopathic fenestrations of the mediastinum.

## Methods

We performed a literature search on the buffalo chest in bison and its etiology. MEDLINE, PubMed, and Google Scholar were searched for articles. The following key words and Medical Subject Heading terms were used: buffalo chest, pleuropleural communication, bilateral pneumothorax, simultaneous bilateral pneumothorax, pneumothorax in bison, mediastinum in bison, anatomy of bison, pneumothorax in animals, anatomy of mediastinum, embryological development of the lungs, and embryologic development of pleural cavity. Reference lists of relevant papers were checked. Eligible papers were reviewed by two researchers (M. M. J. B. and I. S.), and data were extracted on patient demographic characteristics.

We identified a total of 47 cases of patients with a buffalo chest in 34 different case reports.<sup>3-36</sup> Most of these were case reports that mentioned patients who had undergone previous (cardio)thoracic surgery<sup>3-21</sup> (Table 1). It is known that (cardio)thoracic surgery can result in bilateral pleural fenestrations that can become a persistent interpleural communication in the mediastinum. Primary or secondary unilateral pneumothoraces could therefore result in airflow to the contralateral pleural cavity through the interpleural communication and subsequently generate a bilateral pneumothorax.

This condition is known by many clinicians because of a particular anecdote which stated that Native Americans could kill North American bison (*Bison bison*) with a single arrow or gunshot in the chest by creating a bilateral pneumothorax. Even though it is stated that the buffalo chest is a very rare condition,<sup>2</sup> we were surprised that almost every pulmonologist, surgeon, and radiologist of whom we requested information remembered a specific case of a patient with a buffalo chest.

Schorlemmer et al<sup>3</sup> were the first authors who introduced the term buffalo chest in 1984. They reported a case of a simultaneous bilateral pneumothorax following a subclavian venous catheterization in a patient who had undergone a median sternotomy causing a communication of both pleural cavities. In their article, they referred to a “personal communication” by a veterinarian named Dr Kenneth Throlson. He had told them that the interpleural communication in their patient could be compared with an anatomical entity he found on occasion in the North American bison. He thought this was also known by Native Americans who used this knowledge for hunting bison. With a single chest wound they killed their prey by causing a bilateral pneumothorax that resulted in a rapid death.

The other 15 case reports mentioned 16 patients with no history of cardiothoracic surgery who developed simultaneous bilateral pneumothoraces.<sup>22-36</sup> Six of these patients presented with spontaneous simultaneous bilateral pneumothoraces.<sup>22-24,30,32,35</sup> In the other 10 cases, the pneumothoraces were due to an iatrogenic cause following an unilateral transbronchial biopsy,<sup>25,26</sup> transthoracic lung biopsy,<sup>27</sup> chest tube thoracostomy,<sup>28</sup> pacemaker placement,<sup>29</sup> mechanical ventilation,<sup>33</sup> or tracheostomy,<sup>31,34</sup> or following central venous catheterization of the right subclavian vein<sup>36</sup> in the absence of previous cardiothoracic surgery (Table 2).

Ever since the article by Schorlemmer et al<sup>3</sup> was published, other authors used the term buffalo chest in case reports and textbooks when describing a bilateral pneumothorax.<sup>1,4-11,14-17,19,20,22,28-30,32,37-40</sup> This was often accompanied by the anecdote of a Native American who was able to kill a bison with a single arrow or gunshot to the chest.<sup>1,4-7,11,16,19,20,22,23-25,29,30,38-40</sup> We questioned if this buffalo chest was just a myth or an actual anatomic anomaly in bison.

Because we could not find any literature on the anatomy of the mediastinum of the North American bison, we sent a questionnaire by e-mail to almost 50 Dutch veterinarians. No one could give us any information about communications of the pleural cavities in bison. We then consulted M. L. J. Kik DVM,

**TABLE 1 ]** Simultaneous Bilateral Pneumothorax in Cases With Iatrogenic Communication Between Both Pleural Cavities

| Author                              | No. of Cases | Patient Sex      | Previous Intrathoracic Surgery                                                                                                                                           |
|-------------------------------------|--------------|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Grathwohl and Derdak <sup>4</sup>   | 1            | Male             | Following right-sided pneumonectomy                                                                                                                                      |
| Ikezoe et al <sup>5</sup>           | 1            | Male             | Extended thymectomy by median sternotomy                                                                                                                                 |
| Schorlemmer et al <sup>3</sup>      | 1            | Male             | Right infraclavicular subclavian venipuncture in a patient who had previously undergone median sternotomy associated with coronary artery bypass grafting                |
| Ray and Gupta <sup>6</sup>          | 1            | Not described    | Coronary bypass grafting                                                                                                                                                 |
| Sawalha and Gibbons <sup>7</sup>    | 1            | Male             | Bilateral lung transplantation performed through a transverse thoracosternotomy ("clamshell") incision                                                                   |
| Kwon et al <sup>8</sup>             | 1            | Male             | Following left-sided pneumonectomy                                                                                                                                       |
| Sakamoto et al <sup>9</sup>         | 1            | Male             | Following Nuss Barr, surgical correction of a pectus excavatum, surgery                                                                                                  |
| Engeler et al <sup>10</sup>         | 6            | 3 Male, 3 female | Heart lung transplantation                                                                                                                                               |
| Rali and Manyam <sup>11</sup>       | 1            | Female           | Implantable cardioverter defibrillator placement, atrial lead micro-perforation, or a traumatic pleural puncture either leading to or in the presence of a buffalo chest |
| Lee et al <sup>12</sup>             | 1            | Female           | Heart-lung transplantation                                                                                                                                               |
| Wittich et al <sup>13</sup>         | 3            | 2 Male, 1 female | Heart-lung transplantation, heart transplantation, Blalock-Taussig shunt placed by means of a right thoracotomy                                                          |
| Masuda and Ishida <sup>14</sup>     | 1            | Male             | Resection of an esophageal carcinoma                                                                                                                                     |
| Kawakami and Namkoong <sup>15</sup> | 1            | Male             | Esophagectomy                                                                                                                                                            |
| Johri et al <sup>16</sup>           | 1            | Male             | Thymoma resection                                                                                                                                                        |
| Paranjpe et al <sup>17</sup>        | 5            | Not described    | Heart-lung transplantation                                                                                                                                               |
| Abd-Elsayed et al <sup>18</sup>     | 1            | Male             | Thymectomy                                                                                                                                                               |
| Groarke et al <sup>19</sup>         | 1            | Male             | Esophagectomy and substernal gastric interposition                                                                                                                       |
| Chan and Stark <sup>20</sup>        | 2            | Both male        | Both patients coronary artery bypass                                                                                                                                     |
| Eguchi et al <sup>21</sup>          | 1            | Male             | Esophagectomy                                                                                                                                                            |

PhD, a veterinary pathologist specialized in exotic animals at the University of Utrecht in The Netherlands, and P. Cornillie, DVM, PhD, who specialized in veterinary anatomy at the University of Gent in Belgium. They contacted one colleague in Germany and two veterinarians in the United States, but no one could confirm that bison have fenestrations in their mediastinum. We then decided to search for proof of the existence of the "buffalo chest" in North American bison ourselves.

We aimed to verify the actual presence of a connection between the two pleural cavities in North American bison. First, we were trained to perform autopsies on cows, which had died of natural causes, at the Faculty of Veterinary Medicine at the University of Utrecht (Fig 1). Together with Dr Kik and her colleague Louis van den Boom, DVM, we designed and tested three methods to investigate the existence of interpleural communications in the mediastinum of the North American bison.

The first method was a thorough visual examination of fenestrations of the anterior and posterior mediastinum of the North American bison following a thoracotomy. For the second method, we were inspired by the article of Hata et al.<sup>24</sup> They described a case of a man with a simultaneous bilateral

pneumothorax who was scheduled for a bullectomy via video-assisted thoracoscopy surgery. When they finished their surgery on the right lung and performed an air-leakage test with fluid, they noticed fluid production in the chest tube that was placed on the contralateral side.

We decided to name this method the "thoracic drainage system method," a method in which a 32F chest tube is placed in each pleural cavity of the animal, and water with methylene blue would be instilled on one side. A digital thoracic drainage system with suction<sup>41</sup> would be connected to the chest tube placed on the other side. If an interpleural communication existed, we would see drainage of blue water that was instilled in the contralateral pleural cavity.

For the third method, we inserted water with methylene blue in one pleural cavity after placing a chest tube on one side of the thorax. If the pleural cavity was full of water, we would open the pleural cavity of the contralateral side and perform a thorough visual examination of the pleura to investigate if water crossed the other side through an interpleural communication. The animal was laid on its back while performing this method.

**TABLE 2 ]** Simultaneous Bilateral Pneumothorax in Patients Without History of (Cardio)Thoracic Surgery

| Authors                              | No. of Cases | Patient Sex | Iatrogenic Event                                                      |
|--------------------------------------|--------------|-------------|-----------------------------------------------------------------------|
| Parsons and Detterbeck <sup>22</sup> | 1            | Male        | None                                                                  |
| Jacobi et al <sup>23</sup>           | 1            | Male        | None                                                                  |
| Hata et al <sup>24</sup>             | 1            | Female      | None                                                                  |
| Hartin et al <sup>25</sup>           | 1            | Female      | Unilateral transbronchial biopsy                                      |
| Findik et al <sup>26</sup>           | 1            | Female      | Unilateral transbronchial biopsy                                      |
| Yamaura et al <sup>27</sup>          | 2            | Both male   | Transthoracic lung biopsy                                             |
| Samuel and Mahmood <sup>28</sup>     | 1            | Female      | Chest-tube thoracostomy                                               |
| Darwich and Tyrrell <sup>29</sup>    | 1            | Female      | Pacemaker placement                                                   |
| Bilavsky et al <sup>30</sup>         | 1            | Male        | None                                                                  |
| Himeno and Tamura <sup>31</sup>      | 1            | Male        | Tracheostomy                                                          |
| Bassily-Marcus et al <sup>32</sup>   | 1            | Female      | Following mechanical ventilation                                      |
| Albores et al <sup>33</sup>          | 1            | Male        | None                                                                  |
| Kim and Kim <sup>34</sup>            | 1            | Female      | Following tracheostomy                                                |
| Juvonen et al <sup>35</sup>          | 1            | Female      | None                                                                  |
| Pazos et al <sup>36</sup>            | 1            | Male        | Following central venous catheterization of the right subclavian vein |

## Results

We were invited to the Rotterdam Zoo, Rotterdam, The Netherlands, to perform an autopsy on one of the North American bison that was euthanized for medical reasons other than respiratory problems. We started with placing chest tubes in both pleural cavities. After inserting almost 4 L of water with methylene blue in the right chest tube, we observed no drainage of water in the thoracic drainage system on the contralateral side of the pleural cavity (Fig 2). We continued with our third method by opening the contralateral pleural cavity and investigated the anterior and posterior mediastinum. We did not observe any blue water in the left cavity (Fig 3), indicating there was no sign of a buffalo chest.

Because there is only one small herd of nine North American bison in our country, we decided to go to the United States, where there are larger herds of North American bison, to further investigate the existence of the buffalo chest.

We first went to Benson, a small town in the south of Arizona, to visit Dr. Kenneth Throlson, the veterinarian who, through his “personal communication,” was the first to describe a buffalo chest.<sup>3</sup> A large-animal veterinarian, he had years of experience working with thousands of North American bison. He confirmed to us, that during his work as a veterinarian, he noticed

that a lot of bison died following a fight that resulted in penetration of horns unilaterally in the chest. Out of curiosity, he performed autopsies on these cases and found bilateral pneumothoraces and interpleural communications in the mediastinum in approximately one-half of these bison. Dr Throlson was surprised to learn that his anecdote about the North American bison had turned into “buffalo chest,” a well-established term for a clinical condition in humans.

Dr Throlson brought us in contact with the owner of a large meat-processing plant for North American bison in Brush, Colorado. We were only able to perform our first investigation method, due to the strict slaughter schedule and the fact that the meat could not be approved for human consumption after contamination with methylene blue.

Nevertheless, we were able to investigate the mediastinum of eight North American bison following thoracotomy. Data were collected with photography of the anterior and posterior mediastinum. Two of eight bison had visible fenestrations in their anterior mediastinum (Figs 4, 5), and two bison had visible fenestrations in both the anterior and posterior mediastinum; the other four bison had no visible intrapleural fenestrations.



Figure 1 – Autopsy on a Dutch cow.

## Discussion

Just like in some other mammal species and the North American bison, an idiopathic cause of interpleural communication can occur in humans. Although some articles state this action must be caused by a congenital abnormality,<sup>3,5-7,11,16,20-25,27-30,32,33,35,37-40</sup> little is known about the embryologic development of the lungs and pleurae. Most of our knowledge on human development is based on the work of early embryologists, often published more than a century ago, and is established on embryologic studies in mouse models.<sup>42</sup> The pleural, peritoneal, and pericardial cavities all derive from the intra-embryonic coelom. This primitive body cavity develops in the primitive mesodermal layer of the embryo.<sup>43</sup> Closure of the pericardial-peritoneal canals starts during Carnegie stage



Figure 2 – Failed drainage of fluid in the contralateral pleural cavity after suction with a digital drainage system. <sup>1</sup>Cranial side of the animal. <sup>2</sup>Chest tube present in the left pleural cavity.

12 (26-30 days) and is completed in stage 18 (44-48 days). Between these stages, the mesenchymal ridge grows bilaterally into the pericardial-peritoneal canals until they end up as two separate cavities: the pericardial cavity and the pleural cavity.<sup>44</sup> Norden et al<sup>45</sup> found that mice lacking the Tbox-18 gene did not form this mesenchymal ridge; they also found that the Wilms tumor-1 (Wt1) gene, a zinc finger transcription factor expressed in certain mesoderm-derived tissues as the pleura,<sup>46</sup> plays a role in the closure of the pericardioperitoneal canals. De Bakker et al,<sup>44</sup> who reconstructed the embryos of the mice used by Norden et al<sup>45</sup> into three-dimensional images, support this finding. Lack of these genes in humans could be a possible explanation for a congenital buffalo chest.

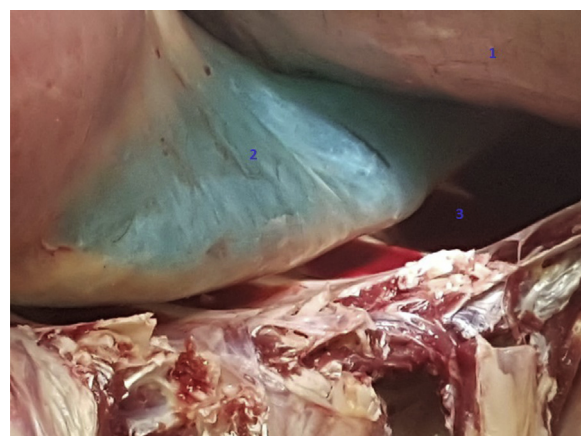


Figure 3 – A closed mediastinum posterior: no leakage of methylene blue. <sup>1</sup>Diaphragm. <sup>2</sup>Posterior junction line. <sup>3</sup>Left pleural cavity.

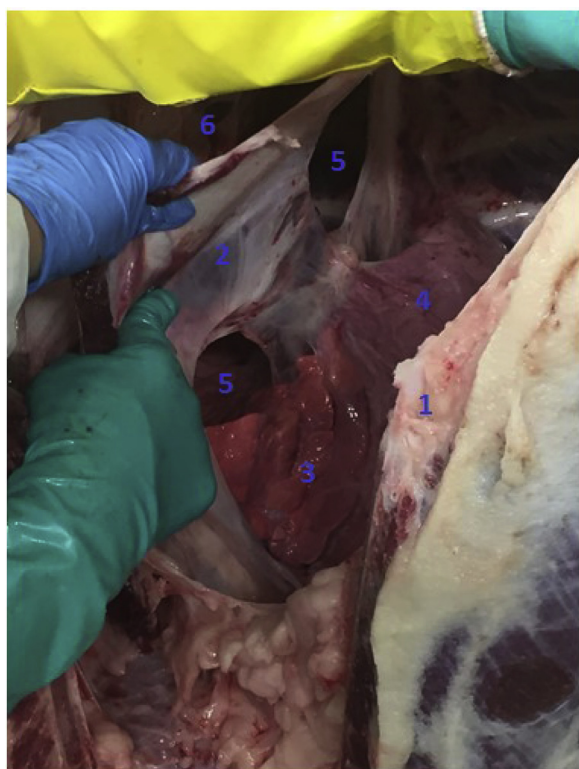


Figure 4 – Fenestrations in the posterior mediastinum in a North American bison, with the animal placed in a head-down position. <sup>1</sup>Sternum. <sup>2</sup>Left pleura parietalis. <sup>3</sup>Left lung. <sup>4</sup>Heart. <sup>5</sup>Fenestrations in posterior mediastinum. <sup>6</sup>Pleural cavity.

In *Thurlbeck's Pathology of the Lung*, it is stated that apoptosis has been observed in all stages of lung development.<sup>42</sup> Although its role and regulation are not well understood, apoptosis probably is the key player in fetal lung development. This could also be a plausible explanation for a congenital buffalo chest. Jacobi et al<sup>23</sup> hypothesized that disruption of the mediastinal pleura from lung metastasis is another possible explanation for developing an interpleural communication.

There are a number of limitations of this study that deserve mention. The study population was small, and we could not perform every method on each North American bison due to strict rules that apply to safe meat processing. It is possible that small fenestrations in both the anterior and posterior mediastinum were overlooked with the first method. These could have been better detected by using the second and third method, which are considered to be more accurate than the first.

For ethical reasons, we decided not to kill bison solely for investigating the mediastinum. This study is important because it brings attention to a condition that



Figure 5 – Fenestrations in the posterior mediastinum of a North American bison, with the animal in a head-down position with the lungs pushed aside. <sup>1</sup>Fenestrations. <sup>2</sup>Lung. <sup>3</sup>Sternum.

was solely based on an anecdote without physical evidence. This evidence was then included in a scientific study. To our knowledge, this study is the first to prove the existence of the buffalo chest.

Fenestrations in the mediastinum have also been noted in dogs, horses, cats, and rabbits.<sup>47–53</sup> For example, in a study of induced pneumothorax in 22 of 24 dogs in which air was injected into one pleural space, these dogs quickly developed bilateral pneumothorax.<sup>47</sup>

Human share many similarities with other mammals in embryologic development. Even though only a few cases of a buffalo chest in humans have been described, we presume that the incidence of interpleural communication in humans is underestimated because it can only be diagnosed if a pneumothorax occurs, or during autopsy if the pathologist focuses on the thorax anatomy regarding this condition. It is therefore important to always pay attention to the contralateral chest when a patient presents with a pneumothorax.

The presence of an interpleural communication can be advantageous. At least in theory, bilateral pneumothorax or effusions in the presence of an interpleural

communication could be treated with just one chest tube, thereby avoiding the need for and risks of an additional chest tube on the contralateral side.<sup>3,6,10,13,17,23,25</sup> It should be noted, however, that in one case this approach failed and actually progressed to a contralateral tension pneumothorax.<sup>12</sup>

The presence of an interpleural communication also involves a potential disadvantage. In case of a pneumothorax, there is a realistic risk of a contralateral tension pneumothorax at the undrained side, when the interpleural communication functions as a one-way valve. It is important to be aware of this potential risk

and to always consider it if a patient who received a chest tube deteriorates further.

## Interpretation

Many authors have used the term “buffalo chest” when describing a bilateral pneumothorax due to interpleural communications, and many clinicians may be familiar with this condition in humans. Hence, it is important to always examine the contralateral lung when a patient presents with a pneumothorax, because missing a bilateral pneumothorax could have fatal consequences as it can result in hemodynamic deterioration due to a tension pneumothorax.

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