



## NOTE

Surgery

# A retrospective analysis for criteria of surgical intervention in Japanese Black calves with respiratory signs caused by perinatal rib fracture

Sueun KIM<sup>1)</sup>, Mrunmayi Vishwanath NAIK<sup>1)</sup>, Yumi KIRINO<sup>1)</sup>, Hiroyuki SATOH<sup>2)</sup>, Nao TSUZUKI<sup>1)</sup>, Yoshiyuki INOUE<sup>1)</sup>, Kohei KURODA<sup>1)</sup>, Yuichi HIDAKA<sup>1)\*</sup>

<sup>1)</sup>Laboratory of Veterinary Surgery, Department of Veterinary Science, University of Miyazaki, Miyazaki, Japan

<sup>2)</sup>Laboratory of Veterinary Clinical Radiology, Department of Veterinary Science, University of Miyazaki, Miyazaki, Japan

*J. Vet. Med. Sci.*

85(1): 40–43, 2023

doi: 10.1292/jvms.22-0332

Received: 23 July 2022

Accepted: 29 October 2022

Advanced Epub:

17 November 2022

**ABSTRACT.** Medical records of 16 Japanese Black calves with respiratory signs associated with perinatal rib fracture were analyzed, retrospectively, to speculate criteria of surgical intervention for the disease. For this analysis, the severity of respiratory condition was classified into three grades: Grade 1, with no wheezing, Grade 2, with wheezing after excitement but not at rest and Grade 3, with wheezing at rest. Grade 1 (n=3) received only conservative management. Seven of Grade 2 (n=8) and all of Grade 3 (n=5) had surgical management. Clinical outcome was good in all of Grade 1, and the surgical success rate was 83% in other groups. Our result suggests that surgical intervention should be considered for cases with more the severity of Grade 2.

**KEYWORDS:** calf, partial costectomy, rib fracture, surgical criteria, wheezing

Rib fracture of neonatal calves is relatively common event in dystocia at birth, especially with forced extraction and breech presentation [3, 10, 11, 13]. In the calves, a few to multiple cranial ribs are involved [1, 4, 5, 7, 10], and the massive callus formation of the fractured ribs can influence respiratory organs including trachea and lung [2, 7, 10]. Tracheal stenosis is the serious condition resulting from the fracture, but the patient calves develop clinical signs several weeks after birth [2, 4, 13]. The callus formation at thoracic inlet region is estimated to be a major cause of tracheal compression [3, 10, 13]. Their clinical signs include dyspnea with wheezing, tachypnea, tachycardia, coughing, and poor growth [2, 3, 10, 13]. The patient calves may have no respiratory signs, but dyspnea may be induced or exacerbated by excitement or exercise [13]. It indicates that severity of the respiratory sign may reflect the degree of affected trachea. Clinical diagnosis of the disease is based on a history, findings of physical examination and diagnostic images [2, 10, 12, 13]. Palpation of the chest near the elbow joint region may detect callus formation at the costochondral junction and non-symmetrical thoracic walls [5, 10]. Auscultation may be also available for the tentative diagnosis [5, 10, 13]. Endoscopy would be suitable for observation of narrowed trachea [2, 13], but simple radiography would be more useful with less stress [10]. Lateral radiograph demonstrates a narrow trachea and substantial callus over the several ribs in calves with the disease [2, 10]. Computed tomography also helps to confirm tracheal stenosis and the affecting fractured ribs [4, 5, 7, 12].

For the calves with stenosis, there is no response to antibiotics and steroids [13]. Most cases with respiratory symptoms have received conservative or surgical managements [2–6, 10, 13]. The conservative management includes individual stall rest in cool and well-ventilated environment, which may be effective for the patients [6, 13]. On the contrary, as surgical managements, external prosthesis technique [2, 3, 10, 13] and partial costectomy [4, 5] has been conducted for calves with the disease. The surgery with prosthesis procedure has provided low success rate (approximately 30%) and the method will require prosthetic material removal after growth of the patient [2, 3, 10]. Authors and Fujikawa *et al.* reported that partial costectomy led to improvement in the clinical condition of the calves and indicated its availability [4, 5]. In these previous reports, unfortunately, criteria for surgical intervention has yet not been discussed in calves with the disease.

In this paper, authors surveyed and analyzed clinical outcomes of Japanese Black calves with respiratory signs caused by perinatal rib fracture, retrospectively, based on the hypothesis that all cases with this disease would require surgical intervention. The purpose of this report is to speculate the criteria for surgical intervention by retrospective analysis of calves with the disease.

Medical records of 16 Japanese Black calves diagnosed with respiratory disorder caused by perinatal rib fracture were analyzed,

\*Correspondence to: Hidaka Y: yhidaka@cc.miyazaki-u.ac.jp, Laboratory of Veterinary Surgery, University of Miyazaki, 1-1 Gakuen Kibana-dai Nishi, Miyazaki 889-2192, Japan

©2023 The Japanese Society of Veterinary Science



This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial No Derivatives (by-nc-nd) License. (CC-BY-NC-ND 4.0: <https://creativecommons.org/licenses/by-nc-nd/4.0/>)



**Fig. 1.** Radiographic images of calves with tracheal stenosis by perinatal rib fracture. (a) Lateral radiograph of case No. 11 showing severe tracheal stenosis (white arrow) at anterior region of the first rib. (b) Computed tomography image of case No. 13 showing fractured first rib with callus formation and depression into thoracic cavity. The deformed rib closes to narrowed trachea (black arrow).

which were presented to Veterinary Teaching Hospital in University of Miyazaki (2011–2021) and could be definitely confirmed to their clinical outcomes. Three calves in our previous report [5] are also included in this study. In these calves, palpation detected callus marks of rib fracture and unbalance or abnormal thoracic walls. All patients received radiographical examination, simple X-ray photography and/or computed tomography, in order to confirm tracheal condition (Fig. 1). The survey items in medical records include age, sex, body weight, perinatal position, respiratory signs, radiographical severity of tracheal stenosis, types of treatment, and clinical outcomes. Their birth presentations were recorded after interviewing owners and referred veterinarians. All calves had respiratory signs, such as cough, tachypnea and/or wheezing at their farms and their first presentation to our hospital. In this survey, in order to discuss the surgical criteria, the severity of the respiratory condition was classified into three grades. Grade 1 means a calf with not showing wheezing at rest and even after excitement. Grade 2 means an animal with no wheezing at rest but develop after excitement. Grade 3 means an animal with severe wheezing at all times even at rest. The severity of tracheal stenosis was evaluated in simple radiographs of 14 cases. Two cases with only computed tomography were excluded from this evaluation. On lateral radiograph of each case, the maximum diameter of the cervical trachea was regarded as the assumed normal diameter, and the degree of stenosis relative to the normal diameter was calculated and evaluated as less than 50% stenosis or more than 50% stenosis in this report. Twelve of the surveyed calves received surgical intervention of partial costectomy followed by our previous report [5]. In brief, patient calf under general anesthesia is positioned lateral recumbency with lifting the forelimb in order to exposure axillary region. The target ribs, especially the first and the second, were approached via incision of skin and pectoral muscles and dissection of connective tissue around the fractured ribs with callus. Then, partial costectomy was performed in the target bones using an electrical saw. The defect of thoracic wall was covered with pectoral muscles and surgical wound was closed by routine procedure. In addition, time of the surgery, unilateral or bilateral, and additional surgical management were also surveyed. The clinical outcomes of all calves were obtained through the field veterinarians or their owners by email or phone call. The outcomes were simply divided into good (auctioned or fattening) or poor (retarded growth, dead, or slaughter) in this paper, because genetic lineage of the calves, the age at surgery and the number of times of the calves underwent surgery could affect their growth.

Results of this survey are shown in Table 1. The patient calves included 15 males and one female. Among the calves, 14 cases were born with dystocia and 13 cases had breech presentation at birth (Table 1). Calves of cases No. 1 to No. 3 had mild clinical disorders including tachypnea, tachycardia and cough. They had not showed wheezing at rest and even after excitement, resulting in being categorized to Grade 1 as our classification (Table 1). Eight calves of cases No. 4 to No. 11 had no wheezing at rest but clearly developed after excitement, hence classified into Grade 2 (Table 1). Five calves of cases No. 12 to No. 16 were categorized to Grade 3 because they showed severe wheezing all time even at rest (Table 1). In Grade 1 group, calves did not undergo surgery and received conservative management including exercise restriction with or without medication. In this group, tachypnea and cough of the calves were diminished with their growth, and the clinical outcomes of all calves showed good with all auctioned (Table 1). In Grade 2 group, seven of eight calves had surgery, unilateral partial costectomy, and only one, case No. 7, received surgery two times at the same side of thoracic wall. Their clinical outcomes were good for all cases (Table 1). However, one of eight calves in this group, case No. 4, died suddenly after excitement, which had conservative management but no surgery (Table 1). In Grade 3 group, unilateral costectomy was performed in three calves, cases No. 12, No. 15, and No. 16, and bilateral surgery in two calves, cases No. 13 and No. 14. In those two patients with bilateral surgery, their first unilateral surgery could not have improved their respiratory condition and the opposite side was treated the other day by the same procedure as a second surgery. As an additional surgery, the manubrium resection of the sternum was carried out in the case No. 14. In this case, the respiratory condition could not improve completely in spite of the bilateral partial costectomy. Therefore, the tracheal palpation, change of breath sound by moving its head left-right and

**Table 1.** Overview, respiratory symptom grades, radiographical evaluation of trachea, types of treatment and outcome of the calves in this report

No	Age <sup>a)</sup>	Sex	BW <sup>a)</sup> (kg)	Parturition (position)	Clinical signs	Grade <sup>b)</sup>	Tracheal stenosis <sup>c)</sup>	Treatment	Outcome
1	17	M	ND	Normal	Tachypnea, tachycardia	1	<50%	Conservative management	Good (auctioned)
2	30	M	74	Dystocia (breech)	Tachypnea, tachycardia	1	<50%	Conservative management	Good (auctioned)
3	120	M	144	Normal	Cough	1	<50%	Conservative management	Good (auctioned)
4	43	F	45	Dystocia (breech)	Wheezing after excitement	2	>50%	Conservative management	Poor (dead)
5	197	M	201	Dystocia (breech)	Wheezing after excitement	2	ND	Surgery (unilateral costectomy)	Good (auctioned)
6	68	M	85	Dystocia (breech)	Wheezing after excitement	2	<50%	Surgery (unilateral costectomy)	Good (auctioned)
7	30	M	66	Dystocia (breech)	Wheezing after excitement	2	>50%	Surgery (unilateral costectomy ×2)	Good (auctioned)
8	47	M	49	Dystocia (breech)	Wheezing after excitement	2	>50%	Surgery (unilateral costectomy)	Good (fattening)
9	71	M	96	Dystocia (breech)	Wheezing after excitement	2	>50%	Surgery (unilateral costectomy)	Good (auctioned)
10	113	M	102	Dystocia (breech)	Wheezing after excitement	2	>50%	Surgery (unilateral costectomy)	Good (fattening)
11	37	M	66	Dystocia (breech)	Wheezing after excitement	2	>50%	Surgery (unilateral costectomy)	Good (fattening)
12	30	M	65	Dystocia (breech)	Wheezing at rest	3	>50%	Surgery (unilateral costectomy)	Poor (slaughter)
13	33	M	71	Dystocia (breech)	Wheezing at rest	3	ND	Surgery (bilateral costectomy)	Good (auctioned)
14	24	M	58	Dystocia (breech)	Wheezing at rest	3	>50%	Surgery (bilateral costectomy, resection of manubrium of sternum)	Good (auctioned)
15	94	M	96	Dystocia (breech)	Wheezing at rest	3	<50%	Surgery (unilateral costectomy)	Poor (slaughter)
16	60	M	97	Dystocia (anterior)	Wheezing at rest	3	>50%	Surgery (unilateral costectomy)	Good (fattening)

a) First referral day. b) Grade 1, not showing wheezing even after excitement; Grade 2, no wheezing at rest but wheezing after excitement; Grade 3, wheezing even at rest. c) Decrease percentage in tracheal diameter on radiograph. M, male; F, female; BW, body weight; ND, no data.

up-down, and CT images were re-evaluated. The results indicated that the trachea was lifted dorsally from ventral aspect by dorsal displacement of the manubrium of the sternum at thoracic inlet. Complete remission after the resection supported the displacement. In this Grade 3 group, three calves, cases No. 13, No. 14 and No. 16 showed decreased wheezing after the surgery and had good outcomes, either auctioned or fattening (Table 1). But two calves in Grade 3 group, cases No. 12 and No. 15, treated with the unilateral surgery resulted in poor prognosis (Table 1). Case No. 12 showed retarded growth and re-developed wheezing three months after the surgery. In Case No. 15, the unilateral surgery could contribute to alleviation of the wheezing, but complete improvement of respiration sound was not observed one-month post-operation. Their owners declined to keep them in farms, and the animals were slaughtered.

In this paper, authors surveyed and analyzed on relations among the severity of respiratory symptom, treatment options and clinical outcomes in calves with tracheal stenosis caused by perinatal rib fracture, which had a purpose to speculate criteria of surgical intervention for calves with the disease. As an indicator, authors focused on the severity of wheezing in the calves, and the patients were conventionally classified into three grades. The result suggested desirable prognosis in the calves classified into Grade 1 with only conservative management and relatively good outcomes with success rate 83% (10/12) of the surgery in the calves classified to Grade 2 and Grade 3.

There have been no articles concerning grade classification for tracheal stenosis in bovine. In dogs, particularly small-breed dogs, tracheal collapse is graded [8]. The grading can be helpful for determining the need for surgical intervention [8]. The severity would be correctly evaluated by endoscopy or fluoroscopy [8, 9]. On the contrary, their diagnostic tools are uncommon in bovine practice, and simple radiography is routine for just the diagnosis of tracheal stenosis. Certainly, Holschbach *et al.* [6] also indicated that the prognosis for calves with tracheal collapse caused by perinatal rib fracture might be involved by the length of the collapsed or stenotic portion of the trachea and the extent to which callus formation on thoracic inlet. In our calves, however, the severity of respiratory sign was regarded not to be always correlated with the degree of tracheal stenosis on radiographies. The reasons are still unknown. Exposure angles of radiation beam, respiratory phase and rotated axis of trachea are the factors that authors speculate. Fluoroscopic dynamic observation of the trachea would be required for correct evaluation in calves as the same as in dogs. In addition, utility of computed tomography was also recommended for the diagnosis and the surgical strategy [4, 5], but bovine clinicians could not routinely use the device in fields. In this paper, authors estimated that the severity of wheezing in the calves would be regarded to be an available indicator representing the severity of tracheal stenosis and had grading among the calves. For bovine clinicians, the wheezing, obvious symptom, can be easily observed and evaluated regardless of the rest condition or after excitement. Furthermore,

the grading was suitable for authors to discuss relations between the treatment options and clinical outcomes.

In our result, two calves of Grade 3 had tentative alleviation of their wheezing after the surgery, but they showed retarded growth, recurred wheezing or partial remission. The owners determined early slaughter of them. Furthermore, two times of unilateral or bilateral surgery was required for complete remission of the symptom in three patient calves. Most severe case in this study, case No. 14, would have three-directional compression to thoracic inlet because of achieving complete remission by resection of the manubrium of the sternum after bilateral surgery. Authors had not experienced the influence of manubrium of the sternum in calves with the disease and it would be regarded to be rare condition. These facts may suggest that careful observation and assessment should be given for the calves before and after the surgery even though one- or two-time operation could lead to improvement, tentatively. Tracheal palpation or elevation of the head may also expose the hidden signs in calves with the disease [13]. As reasons of the recurrence and incomplete improvement of the wheezing, a few factors, such as incomplete costectomy, recurrence of callus formation at the resected rib sites and increased diameter of trachea with calf growth, might have been surmised. However, no necropsy was performed in the slaughtered cases, and the causes are still uncertain.

For calves with tracheal stenosis caused by perinatal rib fracture, extra-tracheal prosthesis procedure with or without unilateral resection of the ribs or only resection of the ribs, partial costectomy, were described as surgical options [2–5, 10, 13]. The prosthesis technique can directly expand the stenotic trachea of the patient and will achieve to improve the respiratory condition. However, the prosthesis should be removed after three to four months post-surgery because of obstruction with tracheal growth [2, 3, 10]. Moreover, the success rate of the technique is approximately 30% [2, 13]. Partial costectomy without the prosthesis has also been applied to improve the patient's respiration [4, 5]. This technique is a simple procedure by only resection of the affected ribs with callus formation, especially the first and second ribs [4, 5]. Our previous report mentioned the success rate of this method, which conducted only one operation for each case, showed good prognoses in two of three cases [5], finally showing 66% of success rate. In this paper, the clinical outcome only with just the partial costectomy showed higher success rate of 83%, although three cases, No. 7, No. 13 and No. 14, required bilateral or additional surgeries.

The purpose of this paper was to explore basis of treatment options, conservative management or surgery, in calves with tracheal stenosis caused by perinatal rib fracture. Previous article reported non-surgical resolution in two Holstein calves with the disease [6]. In many calves with the disease, however, the prognosis had been poor and resulted in undesirable outcomes, euthanized or slaughtered [6]. In our result, three calves of Grade 1 could be sold at auction with only conservative management, but one of Grade 2 with the same management had poor prognosis, died. In contrast, almost cases of Grade 2 and Grade 3 received surgical managements, leading to good prognosis. These facts denied the hypothesis that all cases with this disease would require surgical intervention. As this report describes a retrospective analysis for just 16 cases, clinical prospective research would be required to evaluate the grading of respiratory condition in the patient calves as a reliable standard criterion.

In conclusion, our result of analysis in 16 Japanese Black calves with the disease suggested that the treatment options should be selected based on the severity of clinical symptom and indicated that partial costectomy technique without extra-tracheal prosthesis provided favorable outcomes with high success rate in the calves.

CONFLICTS OF INTEREST STATEMENT. The authors have no conflicts of interest to disclose.

## REFERENCES

1. Ahern BJ, Levine DG. 2009. Multiple rib fracture repair in a neonatal Holstein calf. *Vet Surg* **38**: 787–790. [Medline] [CrossRef]
2. Ducharme NG, Desrochers A, Mulon P-Y, Nichols S. 2017. Surgery of the bovine (adult) respiratory and cardiovascular system. pp. 193–222. In: *Farm Animal Surgery*, 2nd ed. (Fubini SL, Ducharme NG. eds.), Elsevier, St. Louis.
3. Fingland RB, Rings DM, Vestweber JG. 1990. The etiology and surgical management of tracheal collapse in calves. *Vet Surg* **19**: 371–379. [Medline] [CrossRef]
4. Fujikawa T, Nagano M, Wada M, Saitou Y, Otomaru K, Miura N, Fujiki M, Kubota C. 2016. Consideration of diagnosis and surgical treatment of tracheal stenosis caused by rib fracture in calves. *J Jpn Vet Med Assoc* **69**: 267–270 (Japanese with English summary).
5. Hidaka Y, Hagio M, Kashiba I, Ando K, Otani Y, Satoh H, Konishi Y, Tsuzuki N, Hokamura J, Kajisa M, Wada M, Kirino Y, Asanuma T. 2016. Partial costectomy for tracheal collapse and stenosis associated with perinatal rib fracture in three Japanese Black calves. *J Vet Med Sci* **78**: 451–455. [Medline] [CrossRef]
6. Holschbach CL, Tolliver SE, Peek SF. 2020. Resolution of tracheal collapse and stenosis without surgical intervention in two Holstein calves. *J Am Vet Med Assoc* **257**: 1051–1056. [Medline] [CrossRef]
7. Ishiyama D, Makino E, Nakamura Y, Uchida M, Shimizu H, Ono M, Horikita T. 2020. Perinatal rib fractures in 18 calves delivered from Holstein dams. *Vet Anim Sci* **10**: 100134. [Medline] [CrossRef]
8. Johnson L. 2000. Tracheal collapse. Diagnosis and medical and surgical treatment. *Vet Clin North Am Small Anim Pract* **30**: 1253–1266, vi. [Medline] [CrossRef]
9. Macready DM, Johnson LR, Pollard RE. 2007. Fluoroscopic and radiographic evaluation of tracheal collapse in dogs: 62 cases (2001–2006). *J Am Vet Med Assoc* **230**: 1870–1876. [Medline] [CrossRef]
10. Rings DM. 1995. Tracheal collapse. *Vet Clin North Am Food Anim Pract* **11**: 171–175. [Medline] [CrossRef]
11. Schuijt G. 1990. Iatrogenic fractures of ribs and vertebrae during delivery in perinatally dying calves: 235 cases (1978–1988). *J Am Vet Med Assoc* **197**: 1196–1202. [Medline]
12. Vermedal H, Arroyo LG, McKenzie C, Baird JD. 2019. Multiple imaging modalities for the diagnosis of tracheal collapse in a calf: A case report. *Can Vet J* **60**: 1111–1114. [Medline]
13. Woolums AR. 2015. Diseases of the pharynx, larynx, and trachea. pp. 579–583. In: *Large Animal Internal Medicine*, 5th ed. (Smith BP. ed), Elsevier, St. Louis.