

Perioperative survival rates after surgery for diaphragmatic hernia in dogs and cats: 92 cases (1990–2002)

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Objective—To determine the survival rates of dogs and cats that underwent surgical treatment for traumatic diaphragmatic hernia within 24 hours of admission and determine whether timing of surgery affected perioperative survival rate.

Design—Retrospective study.

Animals—63 dogs and 29 cats treated surgically for traumatic diaphragmatic hernia.

Procedure—Medical records were reviewed to evaluate associations between perioperative survival rates and variables including timing of surgery in relation to admission and acute versus chronic diaphragmatic hernia.

Results—Among the 92 animals, 82 (89.1%) were discharged alive after surgery. Sixty-four (69.6%) patients received surgical intervention within 12 hours of admission, and 84 (91.3%) received surgical intervention within 24 hours of admission. Median time from admission to discharge was 4 days (2 to 33 days). Data for acute cases (68 dogs and cats) were analyzed separately. Sixty-three (92.6%) patients with acute diaphragmatic hernia received surgical intervention within 24 hours of admission to the hospital, and 59 (93.7%) of these patients were discharged alive. Twenty-nine (42.6%) patients with acute diaphragmatic hernia received surgical intervention within 24 hours of trauma, and 26 of 29 (89.7%) patients were discharged alive. An overall acute and chronic perioperative survival rate of 89.7% was observed in dogs and cats that received surgical intervention within 24 hours of admission.

Conclusions and Clinical Relevance—Results in 68 dogs and cats that underwent surgery within 24 hours of admission suggested that early surgical intervention for acute diaphragmatic hernia was associated with good perioperative survival rates. (*J Am Vet Med Assoc* 2005;227:105–109)

Diaphragmatic rupture resulting from severe changes in abdominal and thoracic pressures can occur after blunt trauma in small animals. Rupture of the thin musculotendinous structure separating the thoracic and abdominal cavities can result in herniation of abdominal organs into the thoracic cavity, leading to life-threatening respiratory compromise and potential entrapment of abdominal organs. Perioperative survival rates ranging

from 54% to 90% after surgical correction of a diaphragmatic hernia have been reported in the literature.^{1–7} The timing of surgical intervention has been identified as a major risk factor for death in dogs and cats treated via herniorrhaphy.^{6,7} Boudrieau and Muir⁶ reported a significantly higher mortality rate when surgery was performed within 24 hours or > 1 year after trauma. Sullivan and Reid⁷ stated that the only indication for immediate surgical intervention was a dilated stomach in the thorax and that all other affected animals should receive 24 to 48 hours of cage rest and stabilization prior to surgery. It is our impression that surgical intervention for cases of traumatic diaphragmatic hernia at the Ontario Veterinary College (OVC) generally takes place shortly after admission and that the perioperative survival rate after surgical intervention is similar to rates reported in the literature. The objectives of the study reported here were to determine the perioperative survival rate of dogs and cats that underwent surgical treatment for traumatic diaphragmatic hernia within 24 hours of admission and examine the effect of timing of surgical intervention on perioperative survival rate in our population. A secondary objective was to examine the association between dyspnea and the timing of surgical intervention with perioperative survival rate.

Criteria for Selection of Cases

Medical records of dogs and cats were evaluated to identify those with traumatic diaphragmatic hernia and treated via surgical intervention at the OVC from January 1990 to December 2002. Diagnosis of diaphragmatic hernia was made by use of radiography and thoracic ultrasound and confirmed by surgical exploration.

Procedures

Medical records of animals that met inclusion criteria were reviewed, and information was collected including species, age, sex, breed, previous illness, the cause of diaphragmatic hernia, hospital evaluation at the OVC, related injuries, treatments prior to and after admission, time from trauma to admission (TA), time from admission to surgery (AS), time from trauma to surgery (TS), surgical findings, intraoperative complications and supportive treatment, postoperative treatments, postoperative complications (including death), time from admission to discharge, and time from surgery to discharge. Animals were classified into survival groups as alive or dead. Animals euthanized after surgery were included in the dead group. Time from trauma to admission was determined from historical reports in the medical record from the owner or referring veterinarian, which identified the time of

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trauma. Time from admission to surgery and TS were determined from hospital admission and anesthetic reports contained in the medical record. Cases with TA ≤ 14 days were considered acute. Cases with TA > 14 days were considered chronic. In addition, surgical reports were used to confirm the acute or chronic nature of the diaphragmatic defect. Dogs and cats with diaphragmatic hernia were also classified as dyspneic or not dyspneic at the time of evaluation on the basis of high respiratory rate or a recorded comment indicating dyspnea in the physical examination section of the medical record or the intensive care flow sheet. Surgical herniorrhaphy was performed via a ventral midline celiotomy approach to the diaphragm in all cases. All patients were ventilated during anesthesia for surgical repair by use of a mechanical ventilator.

Statistical analyses—All statistical analyses were performed with commercial statistical software.^a Statistical analyses were performed to determine whether the timing of intervention (early [≤ 24 hours] vs late [> 24 hours]) was associated with perioperative survival rate (ie, survival until discharge from the hospital) in acute cases of diaphragmatic hernia. Because the outcomes are binary (alive vs dead), the Fisher exact test was applied, and **odds ratios (ORs)** with exact 95% **confidence intervals (CIs)** were estimated. For acute cases, whether the time to intervention was associated with perioperative death versus survival was also evaluated. Intervention times were tested for normality of distribution.^b If normal, or if a log transformation was successful in achieving normality, a 2-sample *t* test was applied.^c Otherwise, the nonparametric Mann-Whitney-Wilcoxon 2-sample test was substituted for the *t* test.^d **Estimated ratios (ERs)** of time to intervention, given that the patient lived, over the time to intervention, given that the patient died (ie, ER alive:dead), were calculated for TA, TS, and AS. Ninety-five percent CIs were calculated. Early intervention was defined as ≤ 24 hours, and late intervention was defined as > 24 hours. Whether animals with acute diaphragmatic hernia that were dyspneic at admission received surgical intervention sooner than animals that were not dyspneic at admission was evaluated. A Mann-Whitney-Wilcoxon 2-sample test adjusted for unequal variance was used to determine whether TA was different for animals that were dyspneic at admission, compared with animals that were not dyspneic at admission.^d Survival outcomes in the dyspneic and nondyspneic groups were compared by use of a Fisher exact test. For all comparisons, $P \leq 0.05$ was considered significant.

Results

Ninety-two cases (29 cats and 63 dogs) were identified that met the inclusion criteria. Twenty-nine cats (18 male [18 castrated] and 11 female [9 spayed]) and 63 dogs (33 male [17 castrated] and 30 female [20 spayed]) were included in this study. Median age was 3.7 years (0.5 to 13.5 years) for cats and 3.6 years (0.17 to 15.5 years) for dogs. Causes of traumatic diaphragmatic hernia in cats included motor vehicle accidents (18/29 [62.1%]), unknown trauma (9/29 [31.0%]),

falling (1/29 [3.4%]), and dog attack (1/29 [3.4%]). Causes of traumatic diaphragmatic hernia in dogs included motor vehicle accidents (52/63 [82.5%]), unknown trauma (9/63 [14.3%]), being gored by a cow (1/63 [1.6%]), and blunt trauma (1/63 [1.6%]).

Twenty-one of 29 (72.4%) cats that underwent herniorrhaphy had dyspnea at admission. Twenty-three of 29 (79.3%) cats had acute diaphragmatic hernia, and 6 of 29 (20.7%) cats had chronic diaphragmatic hernia, as determined on the basis of TA and confirmed by the surgical report description. Twelve of 29 (41.2%) cats sustained other soft tissue traumatic injuries. Three cats required surgical repair of an abdominal wall hernia, 1 cat required nephrectomy, and 1 cat required intestinal resection and anastomosis. Four of 29 (13.8%) cats sustained orthopedic injuries including fractured long bones and fractured ribs, fractured pelvis, or both. One of these cats required a second anesthetic episode to correct coxofemoral luxation. Median TA was 18 hours (range, 4 hours to 2.3 years) in the 29 cats. Median AS was 3 hours (1 hour to 216 hours). Twenty-three (79.3%) had surgery within 12 hours of admission. Twenty-seven of 29 (93.1%) cats had surgery within 24 hours of admission. Twenty-five (86.2%) cats were discharged alive. Median time from admission to discharge was 3 days (2 to 11 days). Four (13.8%) cats died or were euthanized postoperatively; 3 of these cats had acute diaphragmatic hernia. Preanesthetic intensive supportive care in these cats included oxygen administration (3 cats), IV administration of a crystalloid (4), IV administration of a colloid solution (1), and transfusion with packed RBCs (1). One cat required ventilator support after surgery and was euthanized, 1 had traumatic injuries to a kidney and ureter and was euthanized intraoperatively, and 1 died as a result of acute pulmonary edema diagnosed at postmortem examination. The fourth cat had chronic diaphragmatic hernia and was euthanized intraoperatively at the owner's request. All 4 cats that died or were euthanized received intensive supportive treatment (eg, vasopressors, blood products, or both) before, during, or after surgery.

Twenty-six of 63 (41.3%) dogs that underwent herniorrhaphy had dyspnea at admission. Forty-five (71.4%) dogs had acute diaphragmatic hernia, and 16 (25.4%) had chronic diaphragmatic hernia described in the surgical report. Seventeen (27%) dogs sustained other soft tissue traumatic injuries. Four dogs required partial or complete splenectomy, 1 dog required cystorrhaphy for urinary bladder rupture, and 1 dog required intestinal resection and anastomosis. Twenty-one (33.3%) dogs sustained orthopedic injuries including fractured long bones and fractured ribs, fractured pelvis, or both. Ten of 21 (47.6%) dogs required a second anesthetic episode and surgery, including 5 dogs for repair of pelvic fractures, 4 dogs for repair of a femoral fracture, and 1 dog for open reduction of a coxofemoral luxation. Median TA was 48 hours (range, 1 hour to 10 years) for all 63 dogs. Median AS was 3 hours (range, 1 hour to 14 days). Forty-one (65.1%) dogs underwent surgery within 12 hours of admission. Fifty-seven (90.5%) dogs underwent surgery within 24 hours of admission, and 57 (90.5%) were discharged

alive. Median time from admission to discharge was 4 days (range, 2 to 33 days). Six of 63 (9.5%) dogs died or were euthanatized postoperatively. Preanesthetic intensive supportive care in these dogs included oxygen administration (2 dogs), IV administration of a crystalloid (6), IV administration of a colloid (1), and thoracocentesis (1). Of these, 3 had acute diaphragmatic rupture, as determined on the basis of the surgical report. Postmortem examination confirmed that 1 dog died of hepatic and renal hemorrhage, 1 dog died of myocardial degeneration, and 1 dog died of multiple organ failure. Postmortem examination of 3 dogs surgically treated for chronic diaphragmatic herniation confirmed that 1 dog died of pulmonary edema and hemorrhage and 1 was euthanatized after developing anuric renal failure and liver infarction. The third dog, with a large chronic hernia, was euthanatized because of multiple organ failure and sepsis resulting from a large increase in intraperitoneal pressure impeding venous return following an attempt to replace the abdominal organs in a reduced intraperitoneal space. All 6 dogs that died or were euthanatized received intensive supportive treatment before, during, or after surgery.

Overall, 82 of 92 (89.1%) dogs and cats were discharged alive after surgery. Sixty-four (69.6%) dogs and cats received surgery within 12 hours of admission. Eighty-four (91.3%) dogs and cats received surgery within 24 hours of admission. Median time from admission to discharge for these patients was 4 days (range, 2 to 33 days).

Data from 68 acute cases (dogs and cats) were analyzed separately to determine the TA, AS, and TS for this specific population of patients (Table 1). Fifty-four of 68 (79.4%) patients with acute diaphragmatic hernia received surgical intervention within 12 hours of admission to the hospital; 51 of 54 (94.4%) patients were discharged alive. Sixty-three of 68 (92.6%) patients with acute diaphragmatic hernia received surgical intervention within 24 hours of admission to the hospital; 59 of 63 (93.7%) were discharged alive. Twenty-nine of 68 (42.6%) patients with acute diaphragmatic hernia received surgical intervention within 24 hours of trauma; 26 of 29 (89.7%) were discharged alive. Six animals with acute diaphragmatic hernia (3 dogs and 3 cats) died ($n = 4$) or were euthanatized (2) after surgical intervention. Median TA for these animals was 24 hours (range, 7 to 120 hours), and median AS was 4 hours (range, 3 to 27 hours).

Table 1—Median durations to intervention and rates of perioperative survival during various periods for dogs and cats with acute diaphragmatic hernia.

Time (h)	Period		
	Trauma to admission (n = 66; 2 unknown)	Trauma to surgery (n = 66; 2 unknown)	Admission to surgery (n = 68)
0–6	3 h; 8/8	5 h; 5/5	2 h; 43/48
7–12	8 h; 11/14	10 h; 9/11	11 h; 6/6
13–24	21 h; 10/11	18 h; 12/13	22 h; 8/9
25–48	36 h; 15/15	34 h; 10/10	27 h; 3/3
> 48	72 h; 16/18	96 h; 24/27	276 h; 2/2

A formal test of the effect of early versus late intervention revealed no significant difference ($P = 1.00$) in perioperative survival outcomes between cats and dogs treated for acute diaphragmatic hernia, so data for dogs and cats were combined for further analyses. The OR for perioperative survival was not significantly associated with TA for animals that were admitted ≤ 24 hours versus > 24 hours after trauma (OR, 0.51; 95% CI, 0.06 to 2.92; $P = 0.67$), with TS for animals that underwent surgical correction of acute diaphragmatic hernia ≤ 24 hours versus > 24 hours after trauma (OR, 0.83; 95% CI, 0.14 to 4.90; $P = 1.00$), or with AS for animals that underwent surgical correction of acute diaphragmatic hernia ≤ 24 hours versus > 24 hours after admission (OR, 0.38; 95% CI, 0.10 to 27.70; $P = 0.38$).

The TA was not significantly different in patients that survived, compared with patients that died ($P = 0.88$). The ER alive:dead was 1.09 (CI, 0.38 to 3.13; $P = 0.91$). This ratio implied that patients with acute diaphragmatic hernia that lived waited 1.09 times longer to be admitted than did patients that died, but the difference was not significant. The TS was not significantly different between patients that died and those that survived ($P = 0.91$). The ER alive:dead was 1.06 (95% CI, 0.39 to 2.09) and was not significant. The AS was not significantly different in patients that survived, compared with patients that died ($P = 0.09$). The ER alive:dead was 0.67 (95% CI, 0.25 to 1.30).

Time from admission to surgery for cases of acute diaphragmatic hernia was determined to be shorter for patients that were dyspneic at admission, compared with patients that were not dyspneic at admission ($P = 0.007$). An estimate for the ratio of AS for nondyspneic animals to the AS for dyspneic animals was 2.0, with a 95% CI of 1.0 to 6.0. The OR for survival was not significantly associated with dyspnea for animals with dyspnea versus without dyspnea (OR, 1.291; 95% CI, 0.217 to 7.67; $P = 1.00$). Furthermore, the 6 animals that died or were euthanatized were evenly distributed between the dyspneic and nondyspneic groups at the time of admission.

Abdominal organ displacement was detected at surgery in certain acute cases of diaphragmatic hernia. The liver was most frequently herniated into the thorax (46/68 [67.6%]). This was followed by small intestine (38/68 [55.9%]), a portion of the stomach (33/68 [48.5%]), spleen (27/68 [39.7%]), omentum (18/68 [26.5%]), large intestine (7/68 [10.3%]), gall bladder (4/68 [5.9%]), and pancreas (3/68 [4.4%]).

Four animals with chronic diaphragmatic hernia (3 dogs and 1 cat) died ($n = 1$) or were euthanatized (3) after surgical intervention. One dog had a documented traumatic episode 4 years prior to admission, whereas time of trauma prior to admission was unknown for the other 2 dogs and 1 cat. The median AS for these 4 cats and dogs was 48 hours (range, 2 to 48 hours).

Intensive supportive treatment (other than isotonic fluids and oxygen supplementation) was required in the preoperative, intraoperative, and postoperative period in 30 animals (30/92 [32.6%]) and included the administration of dopamine^c (11/92 [12.0%]), dobutamine^f (5/92 [5.4%]), whole blood (10/92 [10.9%]),

packed RBCs (2/92 [2.1%]), fresh frozen plasma (10/92 [10.9%]), human serum albumin^s (4/94 [4.3%]), ephedrine^h (6/92 [6.5%]), and pentastarchⁱ (12/92 [13.0%]) and postoperative ventilator support (2/92 [2.1%]). Twenty-two of 30 (73%) dogs and cats that required intensive supportive treatment had acute diaphragmatic hernia diagnosed on the basis of history and surgical findings. All patients that died or were euthanatized in this study received intensive supportive treatments because of debilitation at admission or deterioration of their condition after herniorrhaphy.

Discussion

The distribution of the sex of the animals was found to be similar among the 92 dogs and cats with diaphragmatic hernia in this study. This differs from a previous report⁶ in which males were overrepresented. Motor vehicle trauma was the most common cause of traumatic diaphragmatic hernia in dogs and cats in our case series. One could speculate that a percentage of cats with unknown trauma were also likely involved in unwitnessed motor vehicle accidents. Dyspnea was the most frequently reported clinical sign among dogs (26/63 [41.3%]) and cats (21/29 [72.4%]) in this series. A substantial percentage of patients had concurrent soft tissue or orthopedic injuries, including some that required additional surgical procedures at the time of herniorrhaphy or during a second procedure. This is supportive of a previous statement that the magnitude of trauma required to cause a diaphragmatic rupture is sufficient to cause multiple traumatic soft tissue and musculoskeletal injuries.⁶

Time from admission to surgery for all cases in this study was found to be short; 69.6% of dogs and cats underwent surgery within 12 hours of admission, and 91.3% of dogs and cats underwent surgery within 24 hours of admission. The overall perioperative survival rate of patients with acute and chronic diaphragmatic hernia in this study was 89.1%. This perioperative survival rate was higher than most perioperative survival rates reported in the veterinary literature. The higher perioperative survival rate in this study may be a result of advancements in anesthetic protocols and intensive supportive care during the time period of the study. Proper preanesthetic oxygenation and intraoperative ventilation, balanced anesthesia, and postoperative supportive care provided in an intensive care unit presumably improved perioperative survival in our population.

Time from trauma to admission for acute cases of diaphragmatic hernia was widely distributed in this study because some patients were admitted several days after trauma. This finding is likely a result of the referral nature of our hospital caseload. This finding may also indicate that a percentage of animals were referred after initial medical stabilization. Conversely, delayed diagnosis or patient deterioration during hospitalization at the referring clinic often leads to the decision to refer unstable patients. One study⁸ reported that in 20% of animals with diaphragmatic hernia, diagnosis was made 4 weeks after trauma, which emphasizes that a delay between trauma and diagnosis is possible. Despite this, 42.6% of patients with acute diaphragmatic hernia received surgical intervention within 24 hours of trauma with an over-

all perioperative survival rate of 89.7% in our study. Perioperative survival rate for animals with acute diaphragmatic hernia (91.2%) in this study was similar to the highest perioperative survival rates reported after delaying surgical intervention to permit patient stabilization. These findings suggest that surgical intervention within 24 hours of diaphragmatic hernia may not have adversely affected perioperative survival rate of dogs and cats that received herniorrhaphy. Evaluation of AS revealed that 92.6% of animals with acute diaphragmatic hernia had undergone surgical intervention within 24 hours of admission to the hospital. A perioperative survival rate of 93.7% for this group suggested that proceeding with surgery soon after admission (within 24 hours of trauma) may not have adversely affected perioperative survival in our population. The ORs for perioperative survival rate were not significantly associated with TA, AS, or TS for animals with early versus late intervention in acute cases of diaphragmatic hernia. This finding is contrary to previously published statements that associate early surgical intervention with poorer perioperative survival outcomes. Although significance was not achieved in this study, the power of the study was only 12.1%, likely because few animals died or were euthanatized. Furthermore, AS for acute cases was significantly different between dyspneic and nondyspneic animals, which indicated that animals with dyspnea received surgical intervention sooner. No difference in survival rate was found between patients with dyspnea at admission, compared with those that were not dyspneic, which suggested that dyspnea was not associated with perioperative survival rate in our population. These findings are contrary to published reports^{6,7} that recommend 24 to 48 hours of stabilization prior to surgery on the basis of poor perioperative survival outcomes in animals that receive early surgical intervention. Results of a recent study⁹ of 60 cases of traumatic diaphragmatic hernia treated surgically within 12 hours of admission also support our findings; the author states that an animal with acute diaphragmatic hernia and severe dyspnea should undergo surgery immediately because some patients die while preoperative stabilization is attempted.

All cats and dogs that died or were euthanatized in this study received intensive supportive treatment. Treatment protocols involving the use of vasopressors, colloids, and blood products are common in severely traumatized patients. In addition, such treatments are often administered to patients that are not progressing as expected or patients that deteriorate after a traumatic injury or surgery. Administration of intensive treatments was possibly related to increased severity of traumatic injury in this group. A limitation of this study was its retrospective nature, which precluded accurate determination of admission status and progression of the patient's clinical condition. However, animals that died were evenly distributed between dyspneic and nondyspneic status at the time of admission. Use of a prospective protocol to provide a trauma score may have helped to further determine any correlation between admission status and death.

Organ displacement associated with diaphragmatic hernia in this study was similar to that in previous

reports^{6,7}; the liver and small intestine were most frequently found within the thoracic cavity. Herniation of a portion of the stomach through the diaphragmatic defect was usually detected at surgery and did not influence the timing of surgery because none of the patients had radiographic evidence of stomach entrapment or dilatation suggesting that emergency surgery was required.

Comparison between patients that underwent surgery \leq 24 hours after trauma and those that received 24 to 48 hours of stabilization prior to surgical intervention would have been ideal. Such a comparison was not possible because of the retrospective nature of this study and the fact that dogs and cats with traumatic diaphragmatic hernia generally received surgery soon after admission. The overall survival rates of 89.7% and 93.7% in patients that were treated via surgical correction of acute diaphragmatic hernia within 24 hours of trauma or admission, respectively, suggest that early surgical intervention (within 24 hours of trauma) may not have adversely affected patient survival in our population.

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- a. SAS/STAT, version 8, SAS Institute Inc, Cary, NC.
 - b. Proc UNIVARIATE, SAS/STAT, version 8, SAS Institute Inc, Cary, NC.
 - c. Proc TTEST, SAS/STAT, version 8, SAS Institute Inc, Cary, NC.
 - d. Proc NPARIWAY, SAS/STAT, version 8, SAS Institute Inc, Cary, NC.

- e. Inotropin, Bristol-Myers Squibb Canada Inc, Montreal, QC, Canada.
 - f. Dobutamine, Abbott Laboratories Ltd, Saint-Laurent, QC, Canada.
 - g. Plasbumin-25, Bayer Inc Healthcare Division, Toronto, ON, Canada.
 - h. Ephedrine, Sabex Inc, Boucherville, QC, Canada.
 - i. Pentaspan, Bristol-Myers Squibb Canada Inc, Montreal, QC, Canada.
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