



In Dogs With Pyothorax Does Medical Management Alone, Invasive Medical Management, or Surgical Management Result in Better Long-term Outcome?

A Knowledge Summary by

Barnaby Dean BVSc, MRCVS ^{1*}

Sophie Adamantos BVSc, CertVA, DACVECC, DipECVECC, MRCVS, FHEA ^{1*}

¹ University of Bristol, Senate House, Tyndall Ave, Bristol BS8 1TH

* Corresponding Author (barneydean@gmail.com)

ISSN: 2396-9776

Published: 05 May 2017

in: Vol 2, Issue 2

DOI: <http://dx.doi.org/10.18849/ve.v2i2.87>

Reviewed by: Shailen Jasani (MA VETMB MRCVS DACVECC)
and Bruce Smith (BVSc MS FANZCVS DACVS)

Next Review Date: 05 May 2019



Clinical bottom line

Currently available literature on canine pyothorax management is low quality, so it is difficult to draw meaningful conclusions from it. With this in mind, however, the literature does suggest that invasive medical management (thoracic drainage and lavage via in-dwelling thoracostomy tubes, and antimicrobial therapy) and surgical management (in conjunction with antimicrobial therapy) of canine pyothorax provide better long-term survival rates compared to non-invasive medical management (antimicrobial therapy, with or without thoracocentesis) alone. More definitive conclusions cannot be made until higher quality evidence (prospective, randomised, blinded) is available on the topic.

Question

In dogs with pyothorax does medical management alone, invasive medical management, or surgical management result in better long-term outcome?

Clinical Scenario

A five-year old male neutered English Springer Spaniel is presented with a two-day history of progressive dyspnea and exercise intolerance. Clinical examination reveals tachypnea, bilaterally reduced heart sounds, and pyrexia. Basic haematology and biochemistry findings are consistent with infection, thoracic radiography findings are consistent with bilateral pleural effusion, and thoracocentesis findings are consistent with pyothorax. Should the patient be treated medically or surgically?

Summary of the evidence

| Bach (2015) | |
|------------------------------|--|
| Population: | Nineteen dogs with pyothorax confirmed by either the presence of intracellular bacteria on cytological examination, or a positive bacterial culture of pleural fluid, that underwent medical management, early surgery (less than 48 hours following hospitalisation) or late surgery (more than 48 hours following hospitalisation). |
| Sample size: | Nineteen dogs. |
| Intervention details: | <ul style="list-style-type: none"> • Thirteen out of 19 dogs had bilateral thoracostomy tubes placed (invasive medical management), and intermittent pleural lavage (with 19.0 +/- 12.1ml/kg warmed crystalloid solution) and drainage was performed two-to-four times daily. • Five dogs were treated surgically (11 median sternotomies, one lateral thoracotomy). • One dog was treated as an outpatient with antibiotics following thoracocentesis. • Antibiotics used were most commonly enrofloxacin and ampicillin for 10 to 120 days (median 33 days). |
| Study design: | Retrospective single-centre data analysis. |

| | |
|--|--|
| Outcome studied: | Overall cost of treatment, survival rate, and duration of hospitalisation. |
| Main findings: (relevant to PICO question): | <ul style="list-style-type: none"> • Seven patients were in the medical treatment group, five were in the early surgery group, and seven were in the late surgery group. • Median cost of treatment was £1933 (range £256-2386) for the medical group, £2930 (range £2549-5246) for the early surgery group, and £6059 (range £3783-7208) for the late surgery group. • All patients in all patient groups survived to discharge and none had experienced recurrence of pyothorax by six months following discharge. |
| Limitations: | <ul style="list-style-type: none"> • The study is retrospective, with a small number of cases. • The results cover a 10-year study period. • The study was performed on data from a single referral teaching hospital. • Some patients (number not stated) were converted to the surgical group from the medical group which adds bias to the results. • The authors' exclusion criteria excluded dogs that died within 24-hours of hospitalisation. • The severity of clinical signs and intensity of each treatment are not discussed or compared between patients groups. • Little attention is given to specific treatment protocols. |

| Boothe (2010) | |
|--|---|
| Population: | Forty-six dogs with pyothorax confirmed by either the presence of intracellular bacteria in pleural fluid or tissue, bacteria recovered via culture of pleural fluid, or both, that underwent either non-surgical non-invasive, non-surgical invasive or surgical treatment. |
| Sample size: | Forty-six dogs. |
| Intervention details: | <ul style="list-style-type: none"> • All dogs were treated with at least one antibiotic, plus thoracocentesis (non-invasive medical, n=7), a thoracostomy tube (invasive medical, 26) with or without pleural lavage and heparin, or a thoracotomy (surgical, 13) and thoracostomy tube with or without pleural lavage and heparin. • Most commonly used empirical (pre-culture and sensitivity) antibiotics were trimethoprim-sulfonamide (n=30), enrofloxacin (24), amoxicillin (23), ampicillin (20), and penicillin (10). |
| Study design: | Retrospective single-centre case series. |
| Outcome studied: | Short-term (survival to discharge) and long-term (survival to 12 months following discharge) survival rate. |
| Main findings: (relevant to PICO question): | <ul style="list-style-type: none"> • Treatment was non-surgical non-invasive in seven patients, non-surgical invasive in 26 patients, and surgical in 13 patients. • Overall short-term survival rate was 74% (n=34). Short-term survival was 29% (2) for non-surgical non-invasive patients, 77% |

| | |
|---------------------|---|
| | <p>(20) for non-surgical invasive patients, and 92% (12) for surgical patients.</p> <ul style="list-style-type: none"> • Most commonly used antibiotics were trimethoprim-sulfonamide (n=30), enrofloxacin (24), amoxicillin (23), ampicillin (20), and penicillin (10). • Five dogs received one antibiotic, 13 dogs received two, five dogs received three, 11 dogs received four, 10 dogs received five, and two dogs received seven, in various combinations. • Overall long-term survival rate was 63% (n=26). Long-term survival was 29% (two) for non-surgical non-invasive patients, 71% (17) for non-surgical invasive patients, and 70% (7) for surgical patients. • Recurrence occurred in three non-surgical invasive patients, and four surgical patients. |
| Limitations: | <ul style="list-style-type: none"> • The study is retrospective, with a small number of cases. • The results cover a 19-year study period. • The study was performed on data from a single referral teaching hospital. • No criteria for treatment selection are stated. • There is significant variation in treatment protocols used between cases within each group. |

| Demetriou (2002) | |
|--|--|
| Population: | Fifty cases (36 dogs and 14 cats) with confirmed pyothorax were evaluated from five referral institutions in the UK and Ireland. |
| Sample size: | Thirty-six dogs and 14 cats. |
| Intervention details: | <ul style="list-style-type: none"> • Seven dogs were treated surgically. • Thoracostomy tubes (invasive medical management) were placed in 48 of the 50 cases. Forty-two of these underwent pleural lavage using 0.5-6L fluid (either isotonic saline, isotonic saline with intrapleural antibiotic solutions (ampicillin and/or metronidazole), or compound sodium lactate. • All animals were given antibiotic therapy. Most commonly used agents were metronidazole, ampicillin, and enrofloxacin/marbofloxacin. |
| Study design: | Retrospective multi-centre case series. |
| Outcome studied: | Complete resolution of pyothorax following the first treatment after presentation, with no evidence of recurrence at the time of re-evaluation. |
| Main findings: (relevant to PICO question): | <ul style="list-style-type: none"> • Six dogs died during the study period, of which one was treated surgically and five were treated medically. • All remaining canine patients survived without recurrence at the end of the five-year study period. • No patients required surgical treatment after medical therapy. • Two surgically-treated cases from which no foreign bodies could be found did not have chest drains placed. |

| | |
|---------------------|--|
| | <ul style="list-style-type: none"> Survival beyond 48-hours after presentation is a positive prognostic indicator for canine pyothorax. |
| Limitations: | <ul style="list-style-type: none"> The study is retrospective, with a small number of cases. The results cover a five-year period. The study was performed using data from five referral teaching hospitals. Data is poorly presented, preventing direct comparisons between medically and surgically managed dogs and cats. |

| Frendin (1997) | |
|--|---|
| Population: | Nine dogs with thoracic empyema of unknown origin. |
| Sample size: | Nine dogs. |
| Intervention details: | <ul style="list-style-type: none"> All dogs were treated with antibiotic therapy and intermittent thoracic drainage. Five dogs had surgery performed following unsuccessful invasive medical management. |
| Study design: | Retrospective single-centre case series. |
| Outcome studied: | Patient survival. |
| Main findings: (relevant to PICO question): | <ul style="list-style-type: none"> Two dogs were euthanised during the early treatment phase. Seven dogs appeared clinically well within two to three weeks following cessation of thoracic drainage. In five dogs (three medical, two surgical cases) there had not been any sign of recurrence three-to-nine (mean five) years following treatment. The remaining two dogs either died despite attempted further management of recurrence, or were euthanised after a thoracic mass was identified. |
| Limitations: | <ul style="list-style-type: none"> The study is retrospective, with a small number of cases. The study is 20 years old. Cases are from a single hospital. The results cover a five year period, with some cases reported from 29 years ago. There is minimal statistical analysis. |

| Johnson (2006) | |
|------------------------------|---|
| Population: | Fifteen dogs with pyothorax who were treated successfully with medical management and a single thoracocentesis. |
| Sample size: | Fifteen dogs. |
| Intervention details: | Unilateral thoracocentesis (non-invasive medical management) was performed in all 15 cases in conjunction with antibiotic therapy. |
| Study design: | Retrospective single-centre case series. |
| Outcome studied: | Survival and lack of relapse as cessation of antibiotic therapy (six to 16 weeks, mean nine weeks) and long-term follow up (mean 27 |

| | |
|--|--|
| | months). |
| Main findings: (relevant to PICO question): | <ul style="list-style-type: none"> • One patient was excluded because a fluid-filled mass (abscess) was identified and surgery was performed. • Duration of clinical signs prior to referral was three days to seven months, median four weeks. • All dogs were considered clinically normal by owners at cessation of antibiotics. • There was no relapse, and all dogs were considered clinically normal at long-term follow up. |
| Limitations: | <ul style="list-style-type: none"> • The study is retrospective, with a small number of cases. • The results cover a seven-year period. • The results are from a single referral hospital. • Only one of the 15 cases had concurrent thoracic pathology identified (adhesions). • There is no explanation of how long-term assessment is performed. • Only seven effusions were culture positive, so antibiotic therapy was empirical rather than based on culture results in eight cases. |

| | |
|--|---|
| Lee (2014) | |
| Population: | Dogs with pyothorax. |
| Sample size: | Not applicable. |
| Intervention details: | Not applicable. |
| Study design: | Literature review. |
| Outcome studied: | Not applicable. |
| Main findings: (relevant to PICO question): | <ul style="list-style-type: none"> • Pyothorax in patients treated with antibiotics alone or no treatment is often fatal. • The primary complication of various treatments is recurrence of pyothorax. • No definitive algorithms are presented by previous studies for management of pyothorax in dogs. • There is significant treatment failure in canine pyothorax. • No randomised, prospective studies are available. • One-hundred percent success has been reported in a case series of 15 canine patients where a single ultrasound-guided thoracocentesis was performed, followed by antibiotic therapy for a minimum of six weeks. • Repeated thoracic lavage and draining via indwelling thoracic drains is suggested by multiple studies. • Of six cases of canine pyothorax managed surgically in one study, surgery was indicated as a result of: diagnostic imaging results suggestive of a foreign body in three cases, draining sinus in one case, and pleural or mediastinal masses in two cases. |
| Limitations: | <ul style="list-style-type: none"> • The review adds nothing new to the literature. • Very few of the reviewed papers directly compare medical and surgical management of canine pyothorax. |

| MacPhail (2007) | |
|--|---|
| Population: | Dogs and cats with pyothorax. |
| Sample size: | Not applicable. |
| Intervention details: | Not applicable. |
| Study design: | Literature review. |
| Outcome studied: | Not applicable. |
| Main findings: (relevant to PICO question): | <ul style="list-style-type: none"> • The prognosis for pyothorax is highly variable, and the argument of medical versus surgical therapy has yet to be decided. • Mortality rates vary from 0% (in both non-invasive and invasive medical case series) to 42% (in a combined invasive medical and surgical case series). • Recurrence rates are highly variable, but thought to be higher for <i>Actinomyces</i> spp or <i>Nocardia</i> spp infections. • Thoracoscopy should be considered in the future for both diagnostic and treatment purposes. |
| Limitations: | <ul style="list-style-type: none"> • The review adds nothing new to the literature. • Very few of the reviewed papers directly compare medical and surgical management of canine pyothorax. |

| Meakin (2013) | |
|--|--|
| Population: | Fifteen dogs who developed pyothorax following thoracic surgery, confirmed as neutrophilic inflammation within the pleural cavity based on cytological evidence of bacteria within neutrophils and/or a positive bacterial culture of pleural fluid, within 30 days of surgery. |
| Sample size: | Fifteen dogs. |
| Intervention details: | <ul style="list-style-type: none"> • All dogs received antibiotics and thoracic drainage via thoracostomy drains (invasive medical management). • Two dogs underwent thoracic lavage. • All dogs received broad-spectrum antibiotics prior to culture and sensitivity results, after which appropriate antibiotics were administered as indicated (antibiotics used are not stated). |
| Study design: | Retrospective single-centre case series. |
| Outcome studied: | Prevalence, outcome and risk factors for postoperative pyothorax undergoing thoracic surgery. |
| Main findings: (relevant to PICO question): | <ul style="list-style-type: none"> • Fifteen dogs (6.5%) out of 232 dogs undergoing thoracic surgery developed pyothorax following surgery. • No dogs underwent a second surgical procedure to treat pyothorax. • Six (40.0%) died, four (26.7%) were euthanised, five (33.3%) survived to discharge. • Diagnosis of idiopathic chylothorax, preoperative intrathoracic biopsy and preoperative thoracocentesis were identified as |

| | |
|---------------------|---|
| | independent risk factors for developing postoperative pyothorax. |
| Limitations: | <ul style="list-style-type: none"> • The study is retrospective, with a small number of cases. • Long-term follow-up is not available for all cases. • Patients were suffering from a wide-range of concurrent pathology. • There is no mention of the number of cases being treated for pyothorax in the first place. • Patients were only treated medically so no direct comparison between medical and surgical management can be made. • The study is based on data from a single hospital. • Pyothorax may have been underreported by referring veterinary surgeons after discharge from the referral hospital. |

| Mellanby (2002) | |
|--|--|
| Population: | Eighty-one dogs with pleural and mediastinal effusions. |
| Sample size: | Eighty-one. |
| Intervention details: | Dogs were treated either with placement of chest drains (invasive medical management) and pleural lavage at least twice daily for five to seven days, and were administered broad spectrum antibiotics (antibiotics used not stated) for between four and eight weeks, or with surgery. |
| Study design: | Retrospective single-centre case series. |
| Outcome studied: | Disease free survival time. |
| Main findings: (relevant to PICO question): | <ul style="list-style-type: none"> • Thirteen of 81 cases were suffering from pyothorax. • Treatment was attempted in 11 of the 13 cases. • Three of these 11 cases died either during the placement of chest drains or within 48 hours of exploratory thoracotomy. • Seven of the remaining eight cases recovered completely after initial treatment, and one dog died five weeks following surgery. • Five of the eight dogs who were treated were managed by placement of chest drains which were lavaged at least twice daily for between five and seven days and were administered broad spectrum antibiotics for between four and eight weeks. • The three other dogs were treated surgically. |
| Limitations: | <ul style="list-style-type: none"> • The study is retrospective, with only a small number of cases suffering from pyothorax. • Cases are taken from a single hospital. • Cases cover an eight year period. • The study does not aim to directly compare medical and surgical management of pyothorax, so data (including details or medical management) and comparisons are limited. |

| Piek (2000) | |
|--------------------|--|
| Population: | Nine dogs with pyothorax diagnosed through history, physical |

| | |
|--|--|
| | examination, and radiographic and/or ultrasonographic examination of the thorax. |
| Sample size: | Nine dogs. |
| Intervention details: | <ul style="list-style-type: none"> • After culture and sensitivity, all dogs were treated with antibiotics: either co-amoxycylav alone (n=6), co-amoxycylav and enrofloxacin (1), metronidazole (1), co-amoxycylav and metronidazole (1). • All dogs were also treated with thoracic drains (invasive medical management), and administered thoracic lavage for seven to 12 days (median nine days). |
| Study design: | Retrospective single-centre case series. |
| Outcome studied: | Disease free survival at four week follow up examination, seven week follow up examination, and client telephone contact at least six months following hospitalisation. |
| Main findings: (relevant to PICO question): | <ul style="list-style-type: none"> • At a four week follow-up all dogs were free of clinical signs, and clinical examination was unremarkable. • Thoracic radiography was unremarkable in three dogs at four weeks. • In six of the dogs, pleural lines and small amounts of pleural fluid were still evident at four weeks. Five of these dogs were available for clinical examination and thoracic radiography three weeks later, which were unremarkable. • In eight dogs, follow up client telephone contact revealed no reported relapse. |
| Limitations: | <ul style="list-style-type: none"> • The study is retrospective, with a small number of cases. • The study is 17 years old. • Cases are from a single hospital. • There is minimal statistical analysis. • Underlying causes are not discussed. |

| Robertson (1983) | |
|--|--|
| Population: | Twenty-two dogs with thoracic empyema confirmed by radiographic demonstration of thoracic free fluid and bacterial identification by examination of thoracic aspirates. |
| Sample size: | Twenty-two dogs. |
| Intervention details: | Dogs were treated with antibiotics and either thoracocentesis (non-invasive medical management), chest drain placement (invasive medical management), or surgery. |
| Study design: | Retrospective single-centre case series. |
| Outcome studied: | Survival time, up to time of writing. |
| Main findings: (relevant to PICO question): | <ul style="list-style-type: none"> • Sixteen patients survived to discharge, of which two were euthanised (one treated non-invasive medically, the other treated invasive medically) within four months due to recurrence of signs. |

| | |
|---------------------|---|
| | <ul style="list-style-type: none"> Survival time ranges from zero days (death during investigations) to seven years (up to time of writing). Two patients underwent surgical management, only after medical management alone had failed. |
| Limitations: | <ul style="list-style-type: none"> The study is retrospective, with a small number of cases. The study is 23-years old. There is minimal statistical analysis. There is inconsistent data available for all cases. Long-term follow-up is not available for all cases. Cases only became surgical after medical therapy failed. The study is based on data from a single hospital. |

| Rooney (2002) | |
|--|---|
| Population: | Twenty-six dogs with pyothorax confirmed by cytological examination of pleural fluid, or by positive bacterial culture of a sample of pleural fluid. |
| Sample size: | Twenty-six dogs. |
| Intervention details: | <ul style="list-style-type: none"> Seven patients received medical treatment alone (non-invasive medical management), 12 patients were treated medically for 2-to-14 days and then underwent surgery and so were considered surgical patients, and the remaining seven dogs underwent surgery within two days of initial presentation. All dogs received intermittent thoracic drainage and lavage. |
| Study design: | Retrospective single-centre case series. |
| Outcome studied: | Disease-free interval for patients treated medically and surgically up to one-year following treatment. |
| Main findings: (relevant to PICO question): | <ul style="list-style-type: none"> Patients were disease-free one year following treatment in 25% of medically-managed cases, and 78% of surgically-managed cases. Treatment was 5.4 times more likely to fail in medically-managed cases than surgically-managed cases based on disease-free interval hazard ratio. |
| Limitations: | <ul style="list-style-type: none"> The study is retrospective, with a small number of cases. The results cover a 10-year period. The study was performed on data from a single referral teaching hospital. Those patients that underwent late surgery should be considered as cases of failure of medical therapy. There is significant variation in treatment administered within patient groups. |

| Stillion (2015) | |
|---------------------|-------------------------------|
| Population: | Dogs and cats with pyothorax. |
| Sample size: | Not applicable. |

| | |
|--|---|
| Intervention details: | Not applicable. |
| Study design: | Literature review. |
| Outcome studied: | Not applicable. |
| Main findings: (relevant to PICO question): | <ul style="list-style-type: none"> • Overall survival rate in cases of canine pyothorax is 83% (range 29-100%) in literature published between 2000 and 2015. • Recurrence rates for dogs and cats range from 0-14%, with risk factors for recurrence including infection with <i>Nocardia</i> spp or <i>Actinomyces</i> spp, and inhalation and migration of plant material. • There is no evidence to suggest reliable characteristics that accurately predict patient outcome or long-term survival at initial presentation. • Antimicrobial therapy in combination with thoracic drainage is generally accepted as the mainstay of therapy. • There is a lack of prospective, randomised research. |
| Limitations: | <ul style="list-style-type: none"> • The review adds nothing new to the literature. • Very few of the reviewed papers directly compare medical and surgical management of canine pyothorax. |

Appraisal, application and reflection

All relevant studies identified that discuss the outcome of medical or surgical management of pyothorax, or directly compare outcomes of both medical and surgical canine pyothorax cases, are either retrospective case series, or literature reviews that do not add new information to the literature. Retrospective case series sit low on the hierarchy of evidence, so meaningful clinical conclusions are difficult to draw.

It appears that many cases across these studies are initially medically managed first before escalating to surgical management adding significant bias to their results, and every surgical case appeared to have received medical (either invasive, non-invasive, or both) treatment, therefore it remains prudent to consider that some surgically managed cases may have recovered with medical management alone. Further to this, it appears that pyothorax aetiology is often the deciding factor when it comes to choice of treatment modality, and this alone may bring about variations in survival rates. There also appears to be a wide range of treatment modalities applied in all studies, even between cases within the same patient groups, and there is rarely any mention of criteria for treatment selection.

It appears from consulting the available literature that invasive medical management (thoracic drainage and lavage via in-dwelling thoracostomy tubes and antimicrobial therapy) and surgical management (in conjunction with antimicrobial therapy) of canine pyothorax provide better long-term survival rates compared to non-invasive medical management (antimicrobial therapy, with or without thoracocentesis) alone. However, until higher quality (prospective, randomised, blinded) research directly comparing standardised medical and surgical management of canine pyothorax is made available, it is difficult to draw meaningful conclusions from the available research.

Methodology Section

| Search Strategy | |
|---------------------------------------|--|
| Databases searched and dates covered: | CAB Abstracts via the Ovid platform, covering from 1973 to 2016 Week 51. Medline via the Ovid platform, covering from 1946 to 2017. |

| | |
|---------------------------|---|
| Search terms: | (dog OR dogs OR canine) AND (empyema OR empyema, pleural OR pleurisy OR pleuritic OR pyothorax) |
| Dates searches performed: | January 8 th 2017 |

| Exclusion / Inclusion Criteria | |
|--------------------------------|---|
| Exclusion: | Articles not available in English, single case reports, book chapters, conference proceedings, articles which were not relevant to the PICO question, articles listed on but not provided by the searched databases |
| Inclusion: | Articles available in English which were relevant to the PICO. Articles had to involve more than one animal. Literature reviews were included. |

| Database | Number of results | Search Outcome | | | | | | Total relevant papers |
|---|-------------------|---------------------------------|-------------------------------|-------------------------|-----------------------------------|-------------------------------|---------------------------------|-----------------------|
| | | Excluded – non English language | Excluded – single case report | Excluded – book chapter | Excluded - conference proceedings | Excluded – irrelevant to PICO | Excluded – paper not accessible | |
| CAB Abstracts | 183 | 58 | 2 | 4 | 5 | 98 | 3 | 13 |
| Medline | 139 | 19 | 1 | 0 | 0 | 106 | 1 | 12 |
| Total relevant papers when duplicates removed | | | | | | | | 13 |

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

REFERENCES

- Bach, J.F. Balakrishnan, A. (2015) Retrospective comparison of the costs between medical and surgical treatment of canine pyothorax. *Canadian Veterinary Journal*, 56 (11) pp. 1140-1143.
- Boothe, H.W. et al. (2010) Evaluation of outcomes in dogs treated for pyothorax: 46 cases (1983-2001). *Journal of the American Veterinary Medical Association*, 236 (6), pp. 657-663. <http://dx.doi.org/10.2460/javma.236.6.657>
- Demetriou, J.L. et al. (2002) Canine and feline pyothorax: a retrospective study of 50 cases in the UK and Ireland. *Journal of Small Animal Practice*; 43 (9) pp. 388-394.
- Frendin, J. (1997) Pyogranulomatous pleuritis with empyema in hunting dogs. *Zentralbl Veterinarmed A*, 44 (3), pp. 167-178. <http://dx.doi.org/10.1111/j.1439-0442.1997.tb01098.x>

5. Johnson, M.S. Martin, M.W.S (2006) Successful medical treatment of 15 dogs with pyothorax. *Journal of Small Animal Practice*, 48 (1), pp. 12-16.
6. Lee, K.C.L (2014) Surgical or medical management of pyothorax in dogs? *Veterinary Record*, 174 (24), pp. 605-606. <http://dx.doi.org/10.1136/vr.g3817>
7. MacPhail, C.M (2007) Medical and Surgical Management of Pyothorax. *Veterinary Clinics of North America*, 37 (5), pp. 975-988. <http://dx.doi.org/10.1016/j.cvsm.2007.05.012>
8. Meakin, L.B. et al. (2013) Prevalence, outcome and risk factors for postoperative pyothorax in 232 dogs undergoing thoracic surgery. *Journal of Small Animal Practice*, 54 (6) pp. 313-317. <http://dx.doi.org/10.1111/jsap.12064>
9. Mellanby, R.J. Villiers, E. Herrtage, M.E. (2002) Canine pleural and mediastinal effusions: a retrospective study of 81 cases. *Journal of Small Animal Practice*, 43 pp. 447-451.
10. Piek, C.J. Robben, J.H. (2000) Pyothorax in nine dogs. *The Veterinary Quarterly*, 22 (2), pp. 107-111. <http://dx.doi.org/10.1080/01652176.2000.9695035>
11. Robertson, S.A. et al. (1983) Thoracic empyema in the dog: a report of twenty-two cases. *Journal of Small Animal Practice*, 24 (2), pp. 103-119. <http://dx.doi.org/10.1111/j.1748-5827.1983.tb00419.x>
12. Rooney, M.B. Monnet, E. (2002) Medical and surgical treatment of pyothorax in dogs: 26 cases (1991-2001). *Journal of the American Veterinary Medical Association*, 221 (1), pp. 86-92.
13. Stillion, J.R. Letendre, J.A. (2015) A clinical review of the pathophysiology, diagnosis, and treatment of pyothorax in dogs and cats. *Journal of Veterinary Emergency and Critical Care*, 25 (1), pp. 113-129.



Intellectual Property Rights

Knowledge Summaries are a peer-reviewed article type which aims to answer a clinical question based on the best available current evidence. It does not override the responsibility of the practitioner. Informed decisions should be made by considering such factors as individual clinical expertise and judgement along with patient's circumstances and owners' values. Knowledge Summaries are a resource to help inform and any opinions expressed within the Knowledge Summaries are the author's own and do not necessarily reflect the view of the RCVS Knowledge.

Authors of Knowledge Summaries submitted to RCVS Knowledge for publication will retain copyright in their work, but will be required to grant to RCVS Knowledge an exclusive license of the rights of copyright in the materials including but not limited to the right to publish, re-publish, transmit, sell, distribute and otherwise use the materials in all languages and all media throughout the world, and to license or permit others to do so.

Authors will be required to complete a license for publication form, and will in return retain certain rights as detailed on the form.

Veterinary Evidence and EBVM Network are RCVS Knowledge initiatives. For more information please contact us at editor@veterinaryevidence.org

RCVS Knowledge is the independent charity associated with the Royal College of Veterinary Surgeons (RCVS). Our ambition is to become a global intermediary for evidence based veterinary knowledge by providing access to information that is of immediate value to practicing veterinary professionals and directly contributes to evidence based clinical decision-making.

www.veterinaryevidence.org

RCVS Knowledge is a registered Charity No. 230886.
Registered as a Company limited by guarantee in England and Wales No. 598443.

Registered Office:
Belgravia House
62-64 Horseferry Road
London SW1P 2AF



This work is licensed under a [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/).