Pericardial catheter placement versus needle pericardiocentesis in the management of canine pericardial effusion: a pilot randomized trial

Abstract

Objective

To compare the safety and efficacy of pericardial catheter placement with needle pericardiocentesis in dogs with pericardial effusion (PE)

Design

Prospective, pilot randomized trial.

Setting

University teaching hospital.

Animals

Thirty client-owned dogs requiring pericardiocentesis prospectively recruited between January 2017 and August 2019.

Interventions

Dogs were randomized to undergo PE drainage via indwelling pericardial catheter placement (catheter group) followed by elective drainage every 4-6 hours or needle pericardiocentesis (needle group) repeated as necessary.

Measurements and main results

15 dogs were allocated to the catheter group and 15 to the needle group. Data collected included signalment, cause of effusion, occurrence of arrhythmias pre-, during and post pericardiocentesis, procedural length and details of repeated drainages. There was no significant difference between mean procedural times for pericardial catheter placement (17.7 minutes (±11.8)) and needle pericardiocentesis (12.1 minutes (±8.6)) ($p = 0.192$) or the rate of new arrhythmias in the catheter (36%) and needle (64%) groups ($p=0.24$). Pericardial catheters

were kept in situ for a median of 21 hours (range 14-85). 3/15 (20%) dogs in the needle group required repeated pericardiocentesis within 24 hours of initial pericardiocentesis. Pericardial catheters enabled repeated large volume PE drainage in 4 cases (median 10.6ml/kg, range 8-5-10.6).

Conclusions

Pericardial catheters appear to offer a safe alternative to needle pericardiocentesis. Minimal sedation is required for placement, and they can be placed quickly. Their indwelling nature and use was not associated with a higher rate of arrhythmia compared to that of needle pericardiocentesis alone, and may be beneficial in the event that clinically significant PE recurs.

Abbreviations

PE, pericardial effusion.

VPC, ventricular premature complex

CRI, continuous rate infusion

VT, ventricular tachycardia

EPCD, extended pericardial catheter drainage

IV, intravenous

CT, computed tomography

Keywords

Tamponade, extended pericardial catheter drainage, dog, pericardiectomy, arrhythmia

Introduction

Needle pericardiocentesis is a simple and efficacious technique for treating pericardial effusion (PE) causing cardiac tamponade.[1] However, PE can recur and cause clinical signs, requiring repeated drainage. Repeated pericardiocentesis has been reported to be necessary in 25-31% of cases of canine PE, although the timescale to recurrence of clinically relevant effusion is highly variable.[2, 3]

In people, pericardiocentesis is generally performed through pericardial pigtail catheter placement, with 'extended pericardial catheter drainage' (EPCD) well documented for management and repeated drainage of PE.[4, 5] EPCD refers to the process of continued, elective drainage of PE by indwelling catheter every 4-6 hours until the effusion is minimal in volume (25-100ml/day in people), generally required for approximately 2-4 days.[6-9] This can ease patient management were the PE to recur, but EPCD has also been associated with reduced

recurrence of PE in both malignant and idiopathic effusions and the catheter can also be used for instillation of medications such as sclerosing or chemotherapeutic agents.[4,9-11] Pericardial catheter placement, maintenance and extended drainage has been previously described in dogs in a retrospective study but this did not provide evidence of either a clear advantage or disadvantage of pericardial catheter use.[12]

This prospective pilot study aimed to assess the safety and efficacy of pericardial catheter placement in dogs with PE compared to needle pericardiocentesis. Specifically, to compare procedural length, rate of arrhythmias and PE recurrence between groups.

Materials and methods

A power analysis performed using human and veterinary data suggested the sample size required to detect a clinically relevant decrease in rate of recurrence of pericardial effusion between pericardial catheter and pericardiocentesis groups of 31% to 0% with a power of 0.8 and $\alpha < 0.05$ was 48.[3,13] Therefore this study aimed to recruit 48 dogs. Dogs presenting to a university teaching hospital with PE requiring drainage were eligible for inclusion. Informed owner consent was obtained and the study was approved by the Clinical Research and Ethical Review Board (CRERB) of XXXXXX (reference number 2016 1629). Patients were excluded if owner consent was withheld, if there was a coagulopathic cause for the PE or if there was local dermatological disease. Once enrolled, patients were randomized (using a sealed envelope method) to undergo drainage via indwelling pericardial catheter placement (catheter group) or needle pericardiocentesis (needle group). Information collected included patient signalment, weight and baseline clinicopathological data. A patient-side, 3-lead ECG was placed pre-procedurally and monitored for any arrhythmias for 2 minutes. Periprocedural administration of sedative or anesthetic medication was at the discretion of the attending

clinician. Catheter placement and needle pericardiocentesis were performed in a standard fashion as previously described.[12, 14] Briefly, pericardial catheters were 20cm chest tubes[a] placed percutaneously by a modified-Seldinger technique from the right side as follows: peripheral cannula insertion into the pericardial sac followed by removal of cannula stylet, guide wire insertion via cannula access, cannula removal and catheter positioning over guidewire, guide wire removal and securement of catheter to overlying skin with sutures. Pericardiocentesis was performed by passage of a large bore peripheral intravenous cannula stylette, connected to large bore extension tubing and a three way tap, into the pericardial space from the right hand side. Pericardial catheters remained sutured in place once drainage was complete. The length of the procedure and volume of effusion retrieved were recorded, as well as any arrhythmias reported, antiarrhythmics used (use was at the discretion of the attending clinician) and any additional adverse events reported. The procedural length of pericardial catheter placement was defined as the time from first cannula insertion, to the end of suturing the catheter in place. The procedural length of pericardiocentesis was defined as the time from needle insertion to completion of drainage. Successful drainage was confirmed by a combination of clinical changes, and subjective ultrasonographic assessment of pericardial fluid presence and volume after the procedure. The use of ultrasonographic guidance was at the discretion of the clinician. ECG monitoring was performed during the procedure, and continuously thereafter for 24 hours. Furthermore, post-procedurally, ICU staff were required to observe the ECG for 2 minutes every 4 hours, and make a note of the findings. For the purpose of this study, electrical alternans was not considered an arrhythmia, and ventricular tachycardia was defined as sustained (>30 seconds) ventricular rhythm above a rate of 160 beats per minute.[15] For the catheter group, patients had their pericardial catheter drained electively every 4-6 hours and the volume of fluid obtained recorded. Details of any other catheter drainages not within the study protocol, length of drain persistence and analgesics used

were documented, with these factors being determined by the attending clinician. Cause of pericardial effusion and outcome were also recorded. The causes were grouped as presumed neoplastic or presumed idiopathic based on echocardiography, radiography and/or CT.

Statistical methods

All continuous data was assessed for normality using a Shapiro-Wilk Test and descriptive data calculated as appropriate using commercially available software.[b] Continuous variables were compared using a student's t-test for parametric data, and a Mann-Whitney U test for non-parametric. A Fisher's exact or chi-squared test was used to compare categorical data.

Results

Thirty-one dogs were recruited between January 2017 and August 2019. One dog was randomized to pericardial catheter placement, but rapidly deteriorated to the extent that the clinician elected to perform the fastest technique with which they were most familiar, this being needle pericardiocentesis; this dog was excluded from the study. Fifteen dogs were randomized to each group before it became evident that even the predetermined groups sizes of 24 would not yield sufficient follow up due to attrition. The breeds represented were Labradors (6), German shepherd dogs (4), mastiffs (3), Staffordshire bull terriers (2), boxers (2), crossbreeds (2) and one each of the following breeds: golden retriever, Tibetan terrier, St Bernard, Cairn terrier, border collie, miniature schnauzer, Patterdale terrier, small Munsterlander, husky, English bulldog and Rhodesian ridgeback. The median (range) age of all dogs was 112 (15-167) months. There was no significant difference in age between the groups (111 months (30-167) and 118 months (15-148) for the catheter and needle group, respectively) (p=0.68). The catheter group consisted of 10 male neutered and 5 female neutered dogs. The needle group

consisted of 12 males (5 neutered) and 3 female neutered dogs. There was no significant difference in the proportion of males versus females ($p = 0.68$) but there were significantly more intact dogs in the needle group ($p = 0.006$). There was no significant difference in body weight between the catheter (36.4kg (± 18.3)) and the needle (31.9kg (± 13.2)) groups ($p=0.444$).

Midazolam[c] was the most frequently used sedative for the procedure, being used in 11/15 dogs (73%) from the catheter group (0.2-0.35mg/kg) and 8/15 dogs (53%) from the needle group (0.1-0.3mg/kg). Butorphanol[d] was the second most frequently utilized sedative, being used in 7/15 dogs (47%) from the catheter group, and in 8/15 needle group dogs (53%). One patient was fully anesthetized due to brachycephalic obstructive airway syndrome. Local anesthesia with lidocaine[e] was used in 2/15 catheter dogs (13%), and 8/15 in the needle group (53%).

Pericardial decompression was achieved in all dogs. However, in three dogs from the catheter group, pericardial catheter placement was unsuccessful. In all three cases, it was between pericardial access and guidewire insertion that difficulties were encountered. In one case the guidewire could not be fed through the initial temporary access catheter into the pericardial space due to resistance, and in the other two cases, there was no attempt to pass the guidewire as the clinicians were convinced that the access catheter was no longer in the pericardial space (Figure 1). Amongst the 12 successful catheter placements, 9 were placed on the first attempt, and 3 on the second. The only specific difficulty reported was large patient size making the initial pericardial access difficult. In the needle group, 12/15 procedures were performed on the first attempt, with 2 requiring 2 attempts, and one 3. The only specific difficulty reported was drainage of pleural fluid instead of pericardial. In one dog from the needle group, no pericardial effusion was drained (but the effusion dispersed by puncture). Mean procedural

time was not significantly longer for pericardial catheter placement (17.7 minutes, (±11.8)) compared to needle pericardiocentesis (12.1 minutes (±8.6)) ($p = 0.192$). A significantly larger volume of effusion was removed on first drainage via pericardial catheter (10.9ml/kg (±6.7) compared to first needle pericardiocentesis (3.8ml/kg ±3) ($p = 0.004$). No adverse events involving suspected cardiac chamber puncture were noted in either group.

Arrhythmias

Sinus rhythm was documented pre-procedurally in 11/15 (73%) and 14/15 (93%) dogs in the catheter and needle groups, respectively. The arrhythmias noted were ventricular premature complexes (VPCs) in one dog from the needle group and three from the catheter group, and accelerated idioventricular rhythm (AIVR) plus ventricular tachycardia (VT) in one dog from the catheter group.

ECG during procedure amongst dogs with sinus rhythm

Of the dogs in sinus rhythm pre-procedurally, 13/25 (52%) dogs developed a new arrhythmias during the procedure. 4/11 dogs (36%) had a new arrhythmia in the catheter group compared to 9/14 (64%) in the needle group (Figure 1). There was no significant difference in the frequency of new arrhythmias between these groups. ($p = 0.24$). One of the dogs from the needle group received treatment with lidocaine during initial pericardiocentesis (2 x 2mg/kg lidocaine IV) due to progressive AIVR with multiform complexes.

ECG during the procedure in dogs with pre-existing arrhythmias

In the dogs with pre-existing arrhythmias (n=5), in the catheter group two of the four dogs displayed VT that responded to bolus treatment with lidocaine (2mg/kg). One of these dogs displayed VT prior to the procedure with a reduction in rate of the episodic VT after the

procedure. The other two dogs displayed occasional VPCs, one with an example of 2° AV block. The one dog with pre-existing VPCs in the needle group, continued to have intermittent VPCs during the procedure and hospitalization (Figure 1).

ECG 24 hours post drainage

In the 24 hours post drainage, of the 12 dogs with a catheter in situ, 4 dogs had an ongoing arrhythmia documented, none requiring treatment (Figure 1). In the 15 dogs from needle group, there were three with ongoing arrhythmias, none requiring treatment (Figure 1).

Total frequency of arrhythmias requiring treatment

The total frequency of arrhythmias requiring treatment was 2/15 (13%) in the catheter group. Both of these cases had pre-existing arrhythmias, and one dog's pericardial catheter placement was unsuccessful (no guide wire attempted, only a needle pericardiocentesis was performed). Treatment received was 2mg/kg lidocaine in one dog and 2 x 2mg/kg lidocaine followed by a CRI of 50-70mcg/kg/min in the other (See Fig. 1)

The total frequency of arrhythmias requiring treatment was 1/15 in the needle group. This dog had no pre-existing arrhythmias, but had worsening AIVR with multiform complexes during the initial and a subsequent repeated pericardiocentesis 6 hours later, receiving 2 doses of 2mg/kg lidocaine per pericardiocentesis.

Management post drainage

Post procedural analgesia (buprenorphine[f] 0.02mg/kg and methadone[g] 0.05-0.2mg/kg) was provided to 6 dogs from the catheter group (two of these were single doses, 4 dogs had analgesia continued for between 16 and 18 hours) and 2 dogs from the needle group (one of these was a single dose with the other dog having 2 doses i.e. for 8 hours).

The pericardial catheters remained in situ for a median of 21 hours (range 14-85), and were drained electively every 4-6 hours, except in two dogs in which the study drainage protocol was accidentally not followed for the first 6 and 11 hours. Repeated needle pericardiocentesis during hospitalization was required in 3/15 cases (20%) in the needle group (at 3.5, 6.5 and 17 hours after the initial pericardiocentesis). The cause of pericardial effusion in these three cases was a right auricular mass in two cases, and idiopathic in one.

Amongst the 12 dogs with pericardial catheters remaining in situ the median pericardial fluid production was 0.09ml/kg/hr (range 0 – 0.76) (n=12) over a median of 21 hours. Only one dog had clinical signs of effusion recurrence, with an urgent re-drainage of 10.6ml/kg 12 hours after insertion. This dog had a right auricular mass. The other 11 were drained electively. In four of these cases there were negligible volumes retrieved (<1ml/kg total despite multiple attempts at drainage over a median of 20.5 hours) and in three cases there were single drainages of 8.5, 10.5 and 10.6 ml/kg within 12 hours of catheter placement.

11/12 catheters were removed intentionally and the most common reasons were euthanasia (5/12) or discharge from the hospital (3/12). One dog removed its catheter without complication. No infectious adverse events were reported.

Functional difficulties

One drain appeared blocked on one occasion and required flushing with saline to enable drainage. There were no other reported difficulties.

Outcome

14/15 patients in the catheter group had a presumed neoplastic etiology for their PE compared to 10/15 patients in the needle group (p=0.169). 4/15 patients in the catheter group and 4/15 patients in the needle group underwent elective surgical management within 1 week of presentation. From the catheter group 10 dogs were discharged and 5 were euthanized (due to suspected neoplasia and perceived poor prognosis). In the needle group 12 were discharged and 3 were euthanized (due to suspected neoplasia and perceived poor prognosis). All surgical patients were discharged.

Discussion

This prospective study evaluated the use of pericardial catheters in dogs with PE, demonstrating them to be a safe alternative to needle pericardiocentesis. A primary aim was to assess the recurrence rate over time; however, large numbers of patients were euthanized or discharged for euthanasia, and 8/30 dogs underwent surgical management within 1 week of presentation. Of 15 dogs randomized to pericardial catheter placement, there were only 4 cases that had one placed successfully, that did not have surgical management of their disease, and that were discharged alive from the hospital. This attrition made long term recurrence rates difficult to assess.

The exclusion of a case after enrolment due to a preference for needle pericardiocentesis in the emergency setting is a limitation that may have biased the results. It may also suggest pericardial catheter placement is not always appropriate in emergency settings. However, the procedural length of pericardial catheter placement is not significantly longer than that of needle pericardiocentesis, and experience with the technique may increase over time. It is worth noting that the definition of procedural length for the catheter group was not relative to effusion drainage, because during suturing of the catheter in place, the effusion can readily be

drained by an assistant. Thus, drainage is usually complete prior to the end of the procedure, and procedural length encompasses time to drainage.

The population described in this study is consistent with previous retrospective studies of canine PE, with German shepherd dogs, Labradors and males apparently over-represented.[2] There were high numbers of presumed neoplastic etiologies (80% of the population), with 31-68% reported previously.[2, 16] The rate of VPCs documented prior to drainage was similar (17%) to the 10% that was reported in a previous retrospective study.[3] That study also reported that in 10% of pericardiocentesis events, arrhythmias requiring treatment occurred within 1 hour of the procedure.[3] A retrospective case series assessing the use of pericardial catheters in dogs reported a rate of arrhythmia requiring treatment of 22%. In the current study, the total incidence of arrhythmias requiring treatment was 10%, with no appreciable difference between the needle and catheter groups. Interestingly, atrioventricular conduction abnormalities were detected in a total of 4/30 dogs. These were not of clinical concern, being reported as episodic or single episodes. This has not previously been appreciated, but parallels the vagally induced arrhythmias that predominate in people undergoing pericardiocentesis.[11]

Of the three cases in which pericardial catheter placement was unsuccessful, two cases had no guidewire inserted. This makes their procedure tantamount to a needle pericardiocentesis. Reclassifying these patients as such yields a frequency of arrhythmias in the 24 hours post procedurally of 4/13 (none requiring treatment) in the catheter group, and 5/17 (1 requiring treatment) in the needle group. Anecdotally it has been a concern that the presence of a catheter in the pericardial space may be proarrhythmic. However, there were no cases with an indwelling pericardial catheter that required antiarrhythmic therapy, suggesting that the use of indwelling pericardial catheters is a safe practice. Based on existing literature, to power a study

targeting a significant difference in frequency of arrhythmias between pericardial catheter placement and needle pericardiocentesis, group sizes of more than 250 may be required. Furthermore, ECGs were only assessed for 2 minutes every 4 hours. This may have led to the underestimation of arrhythmias. However, if any of the patients developed an undetected arrhythmia, it is reasonable to assume that these were benign and self-limiting, considering the periodic checks that were performed.

Pericardiocentesis in humans often infers pericardial drain placement, either ultrasound or fluoroscopically guided.[5] The total incidence of complications associated with the procedure (such as arrhythmias, vessel or chamber puncture, air embolism and pneumothorax) ranges from 4 to 10%, but arrhythmias themselves usually occur in less than 1%.[17,18] Arrhythmias therefore seem more common in dogs undergoing pericardiocentesis in comparison to people. The incidence of major complications of pericardial catheter placement in people appears to be improved by echocardiographic guidance, and further by fluoroscopic guidance which now appears routine.[5, 11, 18] During this study, the use of ultrasonographic guidance was at the discretion of the clinician. There was also no standardization of the clinicians performing pericardiocentesis or catheter placement, potentially introducing bias as the level of experience of the clinicians is unknown.

As the only prospective study assessing need for repeat PE drainage in hospitalized dogs, it is important to appreciate a repeated need for pericardiocentesis within 24 hours of 20% in the needle group. Assessing the recurrence of effusion in the catheter group is very difficult due to drainage being performed electively. There were no clinical suspicions of uncontrolled or persistent haemorrhage in any case. However, there were four cases in which clinically relevant volumes of effusion were drained within 24 hours. It is possible that these would have required repeat pericardiocentesis if there were no catheter present. In the setting that repeat

pericardiocentesis may be required during hospitalization with urgency, if there are no significant contraindications to maintaining a pericardial catheter in place (such as local pyoderma), then having one present carries obvious advantages.

In humans, EPCD has been associated with a reduction in the recurrence of idiopathic and postoperative effusions by up to 50%.[8, 19] It is associated with a lack of malignant PE recurrence and also with a reduced number of surgical interventions for management of pericardial effusions.[13, 17, 20] The mechanism of this is proposed to be in fenestration of the pericardium by persistence of the catheter. As discussed, is has not been possible to assess long term benefits of EPCD in this study.

The catheters in this study stayed in place for slightly longer than previously reported (median of 21 hours compared to a median of 18 hours).[12] However, this length of time cannot necessarily be considered EPCD. In people EPCD would generally be performed over 2-4 days, or until effusion production is less than 25-100ml/day, corresponding to approximately 0.015-0.06ml/kg/hour. If EPCD is to be practiced in veterinary medicine, an extrapolated definition based on this would need to be derived. The most common reason for pericardial catheter removal was discharge from the hospital or euthanasia, suggesting that to practice EPCD, dogs would have to remain in hospital longer than usual. This may be a limitation to practicing EPCD in veterinary medicine, but additional indications for pericardial catheter placement may include management of infectious pericarditis, or for repeated drainage pending surgical intervention.

No catheters were removed due to documented complications although one dog did remove its own pericardial catheter. Although there were no difficulties reported other than a transiently blocked catheter in one dog, a lack of effusion recurrence was not confirmed

ultrasonographically when negative pressures were achieved. Obstructions and fluid retrieval, therefore, could have been under-estimated. There were no alternative techniques used to quantify the effusions in this study; it is therefore possible that the higher volume retrieved by catheter placement on first drainage, represented larger volumes of effusion in those dogs, rather than a more efficient drainage. It also remains a possibility that other complications that were not screened for, could have been prevalent in these populations, for example, iatrogenic pneumothorax. In this study, owners were notified prior to enrolment that there would be a potential, minimal, cost differential between the two procedures. It was not perceived that any owners hesitated to enroll due to unpredictable or potential cost differences.

Considering the post procedural opioids used in 6 dogs from the pericardial catheter group and in 2 dogs from the pericardiocentesis group, it is unknown if these were used due to assumed discomfort or in response to a pain assessment. In people it appears anti-inflammatory analgesics are used to manage discomfort associated with the underlying disease more so than persistence of a pericardial catheter.[4]

Conclusion

In conclusion, this study demonstrates that pericardial catheters can be easily and safely placed in a timely manner. The advantage of placement of these catheters is that repeated drainage of effusion can be performed by a suitably qualified person (veterinarian or technician) alone, and that this can be performed without the stress, sedation (incurring cost and risk) and potential complications of repeated needle pericardiocentesis. It also furthers the concept of EPCD which may offer unappreciated advantages that could not be evaluated in this study. The veterinary application, efficacy and potential long term benefits of EPCD would best be assessed with a further prospective study.

Footnotes

[a] 14ga x 20cm (8in) Catheter fenestrated up to 8cm mark, MILA International Inc. Medical Instrumentation for Animals, Kentucky, USA

[b] IBM SPSS Statistics, Version 22, New York, USA

[c] Hypnovel 10mg/2ml, Roche Products Limited, Welwyn, UK

[d] Alvegesic vet. 10mg/ml, Dechra, Shrewsbury, UK

[e] 2% Lidocaine, Braun Melsungen, Melsungen, Germany

[f] Vetergesic 0.3mg/ml, Ceva Animal Health Ltd, Amersham, UK

[g] Comfortan 10mg/ml, Dechra, Shrewsbury, UK

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Figure legend

Figure 1. Schematic representation of case management and arrhythmias throughout study. “No catheter” signifies unsuccessful pericardial catheter placement, “guide wire” signifies attempted passage of guidewire. Where individual cases are described, the order is maintained.