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P-WAVE VARIATIONS IN CENTRAL VENOUS CATHETERIZATION IN A CANINE PATIENT UNDERGOING HEMODIALYSIS: CASE REPORT

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Abstract

A 5 years old, Shar Pei intact female, presented with lethargy, progressive weight loss, pale mucous membrane and severe dehydration (7-10%). The patient was diagnosed with acute on chronic renal disease (ACKD), polycystic kidney disease (PKD) and non-regenerative anemia and was referred for hemodialysis. A central venous catheter was placed under light sedation. During central venous catheterization, the cardiac rhythm was monitored by ECG. A key factor for a favorable outcome of the procedure is to understand the correlation between central venous catheterization and cardiac electrical activity. ECG monitoring goal was to observe alterations in P-wave morphology, which reflects atrial depolarization, during central venous catheterization. By monitoring the P-wave variations with extensive care is possible to observe the valuable cardiovascular dynamics in the context of central venous catheterization, aiding clinicians in optimizing patient care and safety of the procedure.

Key words: *electrocardiogram, P-wave, hemodialysis, central venous catheter, kidney.*

INTRODUCTION

The existence of structural or functional alterations in one or both kidneys for a period longer than three months is known as chronic kidney disease (CKD). In dogs, the disease progresses, although the rate at which it does so varies greatly. In dogs, known indicators linked to the course and result of chronic kidney disease (CKD) include anemia, low body condition score, proteinuria, hypertension, and hypoalbuminemia (Polzin, 2011; Bartges, 2012). Numerous factors, such as glomerular diseases, infections, recurrent ischemic episodes, nephrotoxicity, neoplasia, prior acute kidney injury (AKI), or urinary obstruction, have been linked to the pathophysiology of chronic kidney disease (CKD); however, the etiology of these factors is frequently unclear at the time of presentation and stays unclear over the course of the disease (O’Neill et al, 2013; Rudinsky et al, 2018). Acute-on-chronic kidney disease (ACKD), a sudden decline in kidney function, can occur in animals with stable chronic kidney disease (CKD). AKI and ACKD may have similar pathophysiology, clinical presentations, and laboratory abnormalities (Rudinsky et al., 2018).

Central venous catheterization is frequently used for critically ill patients when peripheral catheters aren't adequate due to vascular fragility or thrombophlebitis. They're preferred for administering blood products or medications and for frequent blood sampling, central venous pressure monitoring, or oxygen saturation monitoring Campbell et al., 2012).

Central venous catheters (CVCs), or central lines, vary in size and lumens. For them to be central venous, the catheter tip should be in the cranial or caudal vena cava. In dogs, if it's inserted into the external jugular vein, it's called a central venous jugular catheter (CVJC) (Hughes et al., 2000).

Hemodialysis is a therapeutic procedure that uses the extracorporeal circulation of a patient's blood to improve azotemia, fluid overload, electrolyte and acid-base abnormalities characteristic of the uremic syndrome. Hemodialysis is used for the management of both acute kidney injury and chronic kidney disease that is refractory to conventional medical therapy (Ștefănescu et al., 2018).

The use of non-invasive and invasive monitoring devices can help veterinary practitioners in the detection of organ dysfunction and patient's state of health (Farry et al., 2018).
Electrocardiography (ECG) is a non-invasive, inexpensive, non-hazardous easy to use diagnostic technique that identifies cardiac arrhythmias, cardiac chamber enlargements, myocardial diseases, ischemia, heart failure, conduction defects (heart blocks, bundle branch blocks) (Wess et al., 2010). Electrocardiogram involves electrodes attaching to the skin and it is frequently used to measure heart rate and heart rate variability. Several electrodes are brought into close contact with the skin, and the ECG is measured from the potential difference between the electrodes. The electrodes must be stable and in close contact with the skin (Ohno et al., 2022).
P-wave indexes are markers of atrial conduction derived from the electrocardiogram. P-wave indexes may reflect the accumulation of subclinical atrial pathology including atrial inflammation, fibrosis, and a quantifiable alteration in atrial conduction (Nattel et al., 2008).
P-wave represents atrial depolarization. The impulse starts in the sinoatrial node on the roof of the right atrium and travels downwards and towards the left (Nattel et al., 2008).
These records provide the foundation for case management and are of particular importance in the critical patient whose treatment plans will likely be detailed and complex, and may change frequently. The fragile physiological state and lack of reserve of these patients will result in little tolerance for missed or incorrect treatments (Farry et al., 2018).

MATERIALS AND METHODS

A 5 years old, 15 kg, intact female Shar Pei, diagnosed with acute on chronic kidney disease and polycystic kidney disease was referred for hemodialysis therapy on October 17th, 2023. The dog was presented with the following symptoms: lethargy, appetite loss, weight loss, dehydration (7-10%, considerable loss of skin turgor), body temperature of 37^{o}C and dry mucous membranes. The complete blood count (CBC) was performed on Vetscan HM5 Hematology (5-part Differential) and determined: white blood cells (WBC), lymphocytes (LYM), monocytes (MON), neutrophils (NEU), eosinophils (EOS), basophils (BAS), LYM%, MON%, NEU%, EOS%, BAS%, red blood cells (RBC), hemoglobin (HGB), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), red blood cell distribution width-coefficient of variation (RDWc), red blood cell distribution width-standard deviation (RDWs), platelet (PLT), mean platelet volume (MPV), plateletcrit (PCT), platelet distribution width-coefficient of variation (PDWc) and platelet distribution width-standard deviation (PDWs).
Serum biochemistry was done on Vetscan VS2 Chemistry Analyzer with a comprehensive diagnostic panel that determined: albumin (ALB), alkaline phosphatase (ALP), alanine aminotransferase (ALT), amylase (AMY), total bilirubin (TBIL), blood urea nitrogen (BUN), calcium (CA), phosphorus (PHOS), creatinine (CRE), glucose (GLU), sodium (NA+), potassium (K+), total proteins (TP) and globulin (GLOB).
Urinalysis was performed on Vetscan UA Urine Analyzer and determined leukocytes, ketones, nitrites, urobilinogen, bilirubin, glucose, protein, specific gravity, pH, blood, ascorbic acid, microalbumin, calcium, creatinine and protein/creatinine.
A comprehensive urinalysis procedure was performed utilizing a urine specimen acquired via ultrasonography-guided cystocentesis. This method involves the precise insertion of a needle through the abdominal wall into the urinary bladder, facilitated by real-time ultrasound imaging guidance, to obtain a sterile urine sample for diagnostic evaluation.
Blood pressure was evaluated with VET BP Doppler with manometer (Figure 1). The Doppler method is a technique used to indirectly measure blood pressure by evaluating the Doppler shift, which refers to the change in frequency of sound waves emitted by blood flow. This method involves using a Doppler device to detect the frequency shift caused by the movement of blood within arteries.
The procedure for ascertaining a patient's blood type encompasses the meticulous identification

of distinct antigens situated on the surface of their erythrocytes, thereby elucidating the precise blood group classification essential for clinical management and transfusion compatibility assessments. For this purpose, it was used a quick test to determine in less than 5 minutes if the patient's blood type is DEA 1.1 positive or negative.

Figure 1. VET BP Doppler kit
used to take the patient's blood pressure

Hemodialysis, hydro-electrolytic rebalancing and partial parenteral nutrition were the main goals of the complex therapy. Rehydration was established by fluid therapy with Ringer continuous rate of infusion (CRI), (rate and dosage: 10 ml/kg/h) for electrolyte rebalancing and partial parenteral nutrition based on levo-amino acids (rate and dosage: 6 ml/kg/24 h, 0.6-0.8 g amino acids/kg/24 h). Enteric dialysis supplements (based on *Streptococcus thermophiles*, *Lactobacillus acidophilus*, *Bifidobacterium longum* and *Lactobacillus casei*), calcium-based phosphorus binders, renal diet and nutritional supplements were introduced as adjuvants in the therapy for supporting kidney functions.

For this patient was chosen Haemocat Signo V 12 Fr (Figure 2). This type of catheter is a temporary double-lumen catheter for extracorporeal blood treatments and specifically designed for use in acute dialysis. Also, this CVC has a length of 20 centimeters and a diameter of 12Fr.

The central venous catheter was placed using the Seldinger method.

Figure 2. Haemocat Signo V 12 FR temporary double-lumen catheter for extracorporeal blood treatments. The central venous catheter used for the patient

The electrocardiogram (ECG) recording and monitoring was performed using Poly-Spectrum 8 Vet Rhythm, 4 clip electrodes with 6-lead ECG (Figure 3).

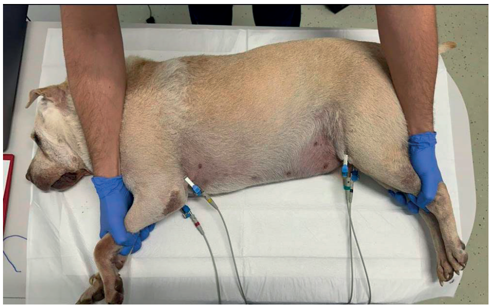

Figure 3. Poly-Spectrum 8 Vet Rhythm, 4 clip electrodes with 6-lead ECG connected to the patient

Electrodes must be positioned as follows: the red one with the inscription RA positioned on the right forelimb, the black one with the inscription RL positioned on the right hind limb, the yellow one with the inscription LA positioned on the left forelimb, the green one with the inscription LL positioned on the left hind limb. The electrodes were placed on the forelimbs and hind limbs, on lateral recumbency in order for the patient to remain calm during this medical examination, this methodological approach was expected to yield comprehensive and reliable information. The electrocardiogram is used to monitor the patient's vital functions and follow the cardio dynamic changes encountered during procedures of this kind.

RESULTS AND DISCUSSIONS

On October 17th 2023, blood biochemistry revealed: BUN 306 (RR: 7-25 mg/dL), CREA 22.9 (RR: 0.4-1.4 mg/dL), K^+ 6.2 (RR: 3.4-5.6 mmol/L), CA 6.6 (RR: 8.6-11.8 mg/dL), PHOS 24.5 (RR: 2.9-6.6 mg/dL). The patient qualified as grade V acute kidney injury with moderate hyperkalemia and hyperphosphatemia based on subsequent accumulation of metabolic toxins (uremia toxins) and dysregulation of fluid, electrolyte and acid-base balance.

Results from complete blood cell count (CBC) showed HGB 3.7 (RR: 12-18 g/dl), HCT 11.96 (RR: 37-55%), MCHC 30.8 (RR: 31-39g/dl) and RDWc 13.5 (RR: 14-20%) consistent with non-regenerative anemia due to low production of erythropoietin by the kidneys. Urinalysis showed UPC ratio of >=0.5 to <2 (proteinuric), pH of 5, microalbumin >=25 mg/L. Arterial blood pressure was 130-140 mmHg systolic, using Doppler method.

In the first day, 24 hours prior intermittent hemodialysis (IHD) session, the patient was submitted to blood transfusion with 450 ml of blood DEA 1 negative in order to manage anemia (the patient was stable during the blood transfusion, normothermic and normotensive), intravenous fluidotherapy for electrolyte rebalancing and partial parenteral nutrition based on levo-amino acids. Calcium based phosphorus binders, renal diet and nutritional supplements were introduced as adjuvants in the therapy in order to support kidney functions.

The placement and installation of the central venous catheter is a key factor for the therapeutic success of hemodialysis. Selecting the appropriate type and size of central venous catheter is crucial in minimizing the risks associated with this medical procedure.

Hemodialysis was decided as an extracorporeal renal replacement therapy.

Electrocardiogram showed a normal pattern during the cardiologic consult (Figure 4), fact that made it possible for the patient to be subject to the intervention of placing the central venous catheter.

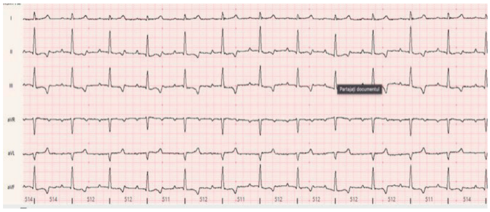

Figure 4. Representation of the patient's electrocardiogram before placement of the central venous catheter

On October 18th 2023 after 24 hours of fluid therapy, a central venous catheter was placed under a light sedation with Alfaxalone and supplemented with oxygen, using aseptic technique (the use of surgical scrub and sterile surgical technique during catheter placement, as well as the use of sterile gloves and the careful handling of catheter line during the procedure).

During the installation of the central venous catheter, it is important to monitor continuously the patient's electrocardiogram in order to observe any changes in the electrodynamics of the heart that may occur during the procedure.

Patients who are afflicted with acute kidney injury often find themselves susceptible to significant shifts in their hydro-electrolytic balance. This intricate balance, governed by the interplay between fluids and electrolytes within the body, frequently manifests in discernible alterations observed on the electrocardiogram. These changes on the electrocardiogram are indicative of the profound impact that the fluctuations in fluid and electrolyte levels can have on cardiac function and rhythm. In this particular case, as depicted in (Figure 4), it was noted that prior to the placement of the central venous catheter, the patient did not exhibit any notable alterations such as cardiac ectopy or arrhythmia, and the electrocardiogram pattern appeared to be within normal parameters.

This type of monitoring helps to ensure the safety of the procedure and well-being of the patient.

At the time of insertion of the central venous catheter, a change in the P-wave was observed on the electrocardiogram (Figure 5).

Figure 5. Representation of the patient's electrocardiogram at the time central venous catheter was inserted

The amplitude of the P-wave changed when the CVC and guide wire were inserted in close proximity of the sinoatrial node through cranial vena cava. At that moment the electrocardiogram registered P-wave elevation arrhythmia in heart electrodynamics. When this arrhythmia occurred, the CVC was withdrawn for approximately 1 centimeter and repositioned slowly. The catheter should be positioned within the vessel lumen. If the catheter enters the right atrium, arrhythmia can be appreciated on the electrocardiogram. Thus, the catheter should be immediately pulled back until the arrhythmia resolves.

Following the withdrawal of the central venous catheter along with the guiding wire, there was a notable observation within a timeframe of approximately 10 seconds: the amplitude of the P-wave exhibited a restorative trend, returning to its baseline level that was evident prior to the initial insertion of the catheter. This phenomenon is visually depicted in (Figure 6), highlighting the dynamic physiological response associated with the removal of the central venous catheter from the close proximity of sinoatrial node.

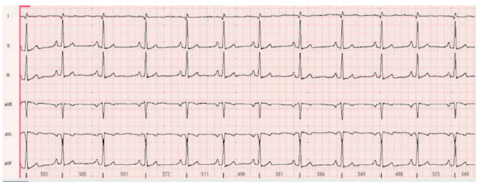

Figure 6. Representation of the patient's electrocardiogram after the central venous catheter was withdrawn approximately one centimeter

It is very important to confirm the correct position of the CVCs tip due to the mechanical stimulation caused by the final part of the central venous catheter exerted on the sinoatrial node (Jain et al., 2011).

CONCLUSIONS

The variations of the P-wave from the normal aspect of ECG prior the catheterization concluding with an elevated P-wave when the guiding wire and the tip of the catheter reached the close proximity of sinoatrial node remain an incredible marker for practitioners to know when they should retract the catheter and the guiding wire.

The introduction of central venous catheter, a temporary double-lumen catheter, on this case, plays a crucial role in facilitating therapies such as hemodialysis, allowing precise fluid management and electrolyte rebalancing.

Placing a central venous catheter is a procedure that involves risks and it has to be made by a surgeon with experience who knows when to retract the catheter. Monitoring that procedure with an electrocardiograph is mandatory in order to avoid any risk associated with malposition of the central venous catheter.

An accurate ECG diagnosis is an important monitoring tool and it can be used to detect and manage cardiac rhythm abnormalities, during the placing of central venous catheter.

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