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Failure of Mitral Valve Repair in a Dog with Severe Mitral Regurgitation

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Abstract : A 10-year-old 4-kg spayed female Chihuahua with severe congestive heart failure was referred for surgical treatment. Through several examinations, the dog was diagnosed as severe mitral regurgitation (MR) and moderate TR. Because of the poor prognosis associated with continuation of medical management, surgical repair of the mitral valve was considered as the treatment option for the dog. The mitral valve repair was performed undergoing cardio pulmonary bypass (CPB) circuit. However after mitral repair, the dog was died without recovery from anesthesia. Many risk factors associated with failure of cardiac surgery are included CPB management, hypothermia, organ dysfunction, hemorrhage, hypotension, electrolyte & acid base imbalance, and infection. Although the dog is died from the operation, it is an important to reveal the factors of failure in veterinary clinic. From the case report, causes of failure of mitral valve repair can be considered from the failure of oxygenation and gas exchange by hypothermia and serious hypotension with low heart rate by low cardiac output syndrome (LCOS). Through the several considerations from this case, it is known that coming cardiac surgery for mitral valve repair is required to be more careful for successful operation. Further it can be brought to increase success rate in further operation.

***Key words* :** mitral regurgitation, mitral valve repair, cardiopulmonary bypass, risk factor, dog.

Introduction

Mitral regurgitation (MR) is the most common acquired cardiac disease in dogs accounting for about 40% of cases in the species (13,15). The cause of MR is chronic degenerative valve disease with myxomatous degeneration of the chordae tendineae or valve leaflets (15,17). Exacerbation of degenerative mitral valve disease is related to the degrees of MR and valvular degeneration and patient age (15). The problem of mitral valve can develop to myocardial disorders or other cardiac diseases because of volume overload of the left side of the heart (3,13,15). The prognosis of degenerative mitral valve disease can be determined due to mitral prolapse, rupture of chordae tendineae and progressive thicken of chordae tendineae (15,17,18). Specific treatments have been used to decrease the severity of MR, to prevent pulmonary congestion, and to manage the cardiac conditions. As a result, objective of the treatments is to improve quality of life for the dog (15,20). The medical treatment of MR includes diuretics, vasodilators, angiotensin-converting enzyme inhibitors and positive inotropic drugs. However, progressive heart failure is the inevitable consequences of severe MR despite medical treatment (17). Therefore, it is thought that mitral valve surgery is one of the radical cures to reduce MR (14). The surgical methods for correction of mitral regurgitation are valve replacement and valve repair (2,3,4,6). Mitral valve replacement with mechanical or bioprosthetic valves have been done in human medicine (1,16). In veterinary medicine, mitral repair is commonly used to maintain the native valve instead of valve replacement (12,17,18). The method of valve repair is technically hard to do and mild valvular insufficiency presents on postoperative repair. However, because dog has a prominent septal leaflet abnormality in contrast with human patients, the result of mitral valve repair are encouraging with 70% of patients surviving surgery (7,15). Although mitral valve repair is good method to decrease MR, there are many limitations and high risk factors to have a failure of the repair surgery in dog. The main factors include management of cardiopulmonary bypass (CPB), hypothermia, organ dysfunction, hemorrhage, electrolyte & acid base imbalance, and infection (11,15). If one of the factors is neglectful treated, mitral valve repair cannot be accomplished. It is an important to reveal the factors of failure in veterinary clinic. From the case report, causes of failure of mitral valve repair can be considered then it can be brought to increase success rate in further operation.

Case

A 10-year-old 4-kg spayed female Chihuahua with severe

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congestive heart failure was referred for surgical treatment. On clinical examination, the dog had diminished health status and exercise intolerance because of pulmonary edema during 3 months. Clinical symptoms were cough, cardiac syncope and respiratory distress. There was a left apical grade 5/6 systolic murmur. The dog was being administered pimobendan (0.3 mg/kg orally every 12 hours), digoxin (0.005 mg/kg orally every 12 hours), furosemide (2 mg/kg orally every 12 hours), spironolactone (1 mg/kg orally every 12 hours), ramipril (0.25 mg/kg orally every 24 hours) and hydrochlorothiazide (2 mg/kg orally every 12 hours). Resting respiratory rate 40 beats/min and heart rate was about 160 beats/minutes. On standard 3-lead electrocardiogram (ECG) there was normal sinus rhythm. In the lateral and dorsoventral radiographic projection, there was tracheal elevation, marked left atrial enlargement and ventricular dilation with pulmonary edema. Two-dimensional (2D) and M-mode echocardiography revealed a mitral prolapse and ruptured chordae tendineae with left atrial enlargement in right parasternal long-axis views. By color flow and spectral Doppler imaging, there was identified severe MR and tricuspid regurgitation (TR) with moderate systolic pulmonary artery hypertension. Complete blood count (CBC) and serum chemistry were presented leukocytosis, increasing alkaline phosphatase (836 U/L; 14-224 U/L as reference range), increasing blood urea nitrogen (83 mg/dl; 6.8-29.6 mg/dl as reference range) and mild hypokalemia (3.4 mEq/L; 3.7-5.6 mEq/L as reference range). Other items were no abnormalities. From the basis of the findings, the dog was diagnosed as severe MR and TR. Because of the poor prognosis associated with continuation of medical management, surgical repair of the mitral valve was considered the only treatment option for the dog.

Anesthesia

The dog was premedicated with atropine sulfate (0.025 mg/kg intravenously), butorphanole (0.2 mg/kg intravenously). Then the dog had an induction with propofol (6 mg/kg intravenously) under oxygenated with 100% oxygen and intubation with an endotracheal tube. Cefazolin (25 mg/kg) was administered before and every 2 hours until the end of the surgical procedure. Anesthesia was maintained with 1.5-2% isoflurane with 100% oxygen at 1.2 L/min. During CPB, anesthesia was kept by intravenous injection of propofol (0.2 mg/kg/min) and butorphanol (0.1 mg/kg/hr) as continuous rate infusions (CRI). The left femoral artery and vein were catheterized for measurement of systolic, diastolic, and central venous pressure, respectively. During surgery, monitoring included heart rate, respiratory rate, core body temperature, SpO2 and end tidal CO2 by physiological monitor (Datex-Ohmeda, GE health care). Urine output was also monitored by placement of urine catheter. Arterial blood gas analysis, activated clotting time (ACT) and serum chemistry were performed using blood samples via the femoral artery catheter as necessary. The dog was positioned in right recumbency for a left 4-5 intercostal thoracotomy.

Cardiopulmonary bypass (CPB)

CPB machine is composed with oxygenator, heart-lung machine, and heat exchanger for extracorporeal circulation. For CPB, small breed dogs are extremely required to control the priming volume due to low circulation, hemodilution, and electrolyte imbalance (MR1). In this case, the priming solution was filled with lactated ringer solution (160 mL), 15% mannitol (13.3 mL), 8.4% sodium bicarbonate (8 mL), heparin (5000 IU/ml: 0.5 mL), and antibiotic (Cefazolin: 0.5 mL). In addition, the priming fluid was replaced with cross-matched blood supplement for the dog. After fourth intercostal thoracotomy, the pericardium was retracted to expose the left atrium & ventricle. Before the incision of left atrium, cardioplegic catheter was placed at the aortic root to induce cardioplegia. Heparin sodium (200 IU/kg) was administered through the cephalic vein to prevent blood coagulation. Then, activated clotting time (ACT) after heparin injection measured to compare with normal clotting time. Five minutes after heparin injection, ACT is confirmed to be over 200 seconds. Body core temperature was adjusted at 25 to 30ºC to minimize organ damage during CPB. The 8Fr arterial cannula was connected to the carotid artery and 12Fr venous cannula was connected to the jugular vein for blood drainage. After arterial and venous cannulation, the cannulas were connected to CPB circuit. Micro-air bubble was completely removed from the circuit, and partial CPB was started to control the body temperature at 30ºC. The priming volume of the circuit was 180 mL for the dog. When the temperature was lowed to 30ºC, an arterial clamp was taken to the aorta and the cardioplegic solution (15 ml/kg: Custodiol solution, Bensheim, Germany) was rapidly injected into the coronary artery. Anesthesia was switched from isoflurane anesthesia to injectable anesthesia combined with propofol and butorphanol.

Surgical procedure (Fig 1)

After the pericardium was opened, initial procedure was an examination of the mitral valve through the left atrium incision. The ruptured chordae tendineae was confirmed visually. The mitral valve repair was performed by combination of edge-to-edge method and artificial chordae replacement. The edge-to-edge method can be used when the prolapse is central area of the valve, the anterior and posterior leaflets are approximated "edge-to-edge" one mattress suture (10). Buttressed horizontal mattress sutures of non-absorbable suture material were placed in leading edges of central portion of each leaflet. A double-orifice mitral valve was created (10). The chordal replacement was created by use of No. 5-0 polytetrafluoroethylene (PTFE) sutures. A double-armed suture was passed through the papillary muscle and each arm was also passed the leaflet and tied. At that time, temporary guy-line stitch was placed at the prolapsed leaflet. Tying tension was determined by height and length between native anterior leaflet and artificial PTFE chordae. After the mitral valve repair, left atrium was routinely closed.

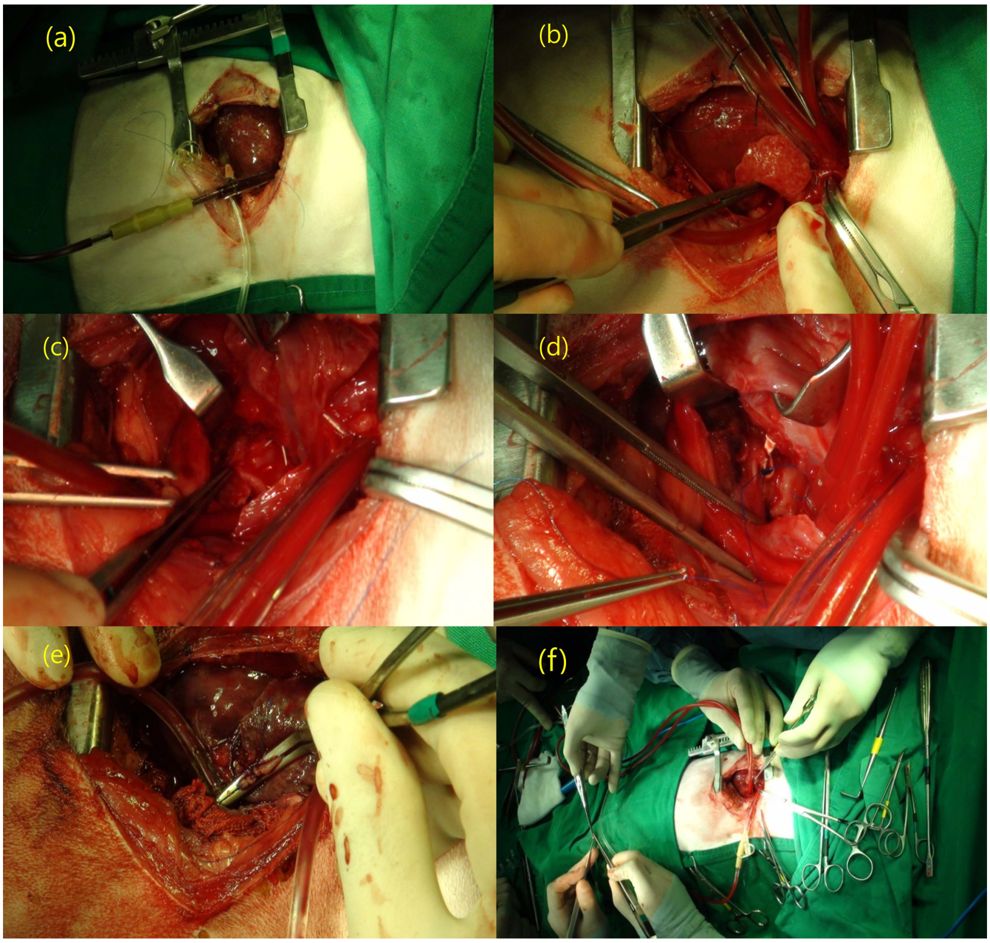

Fig 1. Surgical photographs of mitral valve repair. (a): opening the pericardium and preparation of cardiac arrest by cardioplegia injection at a catheter of aortic root; (b): approach of mitral valve through left atriotomy; (c): artificial chordal replacement with 5-0 polytetrafluoroethylene (PTEF) sutures; (d): "edge-to-edge" method; (e): closure of left atrium; (f): preparation of chest closure.

Weaning procedure

After the left atrium was closed, concurrently the dog was started to rewarm at 37ºC. The aortic cross clamp was removed and the patient did start spontaneous heart beating slowly. The cardioplegic time was about 100 minutes. However, the dog was not recovered without CPB despite of normal body temperature. As CPB flow was reduced, the cardiogenic parameters were also decreased. Although inotropic agent was used to improve the physiologic condition, it was not working. Finally the dog was died.

Discussion

This is the first report for dog to be described on surgical repair of mitral valve regurgitation in our country. Although the dog is eventually died, it is worthy considering the causes of failure of mitral valve repair for success of future operation. Open heart surgery such as valve repair or replacement is required many considerations. The main considerations include CPB management, hypothermia, organ dysfunction, hemorrhage, hypotension, electrolyte & acid base imbalance, and infection (9,11). If just one of all the considerations misses during surgery, the patient should not be recovered from the surgery (19).

The management of CPB is the most important thing to take open heart surgery with extracorporeal circulation (15). In veterinary medicine, CPB has been used to repair cardiac problems seen in small animal patients. Since CPB was used firstly at 1973, it has been remarkably developed in equipment and engineering skill (15). Nevertheless, accidents unexpectedly happen such as mechanical problem, air embolization, and electrical shut down. However if dog or cat are small size patients, it is very difficult to control the limited volume (8). To do the bypass, sufficient volume needs to circulate the whole CPB tube. Usually hemodilution method, which is added with priming solution, has been used and patient hematocrit can be maintained at 20%. In this case, the dog was partially replaced with whole blood of universal donor. A skillful doctor managed CPB control and it was not happened any mechanical crisis during CPB.

Because small animals present a difficulty in the control of volume and flow rate under normothermic condition, veteri-

Table 1. Blood gas analysis

	OP	OP+30	CPB	CPB+30	Postop	Postop+30
pH(7.36-7.44)	7	7.08	7.35	7.19	7.27	7.23
PCO2(36-44)mmHg	60	62	24	14	9	8
Hco3(24-26 mmol/L)	16	16.9	12.4	4.9	22	28.7
PO2(90-100 mmHg)	180	183	158	379	490	359
tHb(12-18)g/dL)	7.4	7.4	7.4	6.2	6.3	7.5

Table 2. Blood analysis

	OP	OP+30	CPB	CPB+30	Postop
ALB(2.2-3.9)	2.6	2.2	2.2	2.2	2.3
ALP(23-212)	1062	385	336	60	8.5
ALT(10-100)	270	141	206	162	221
AMYL(500-1500)	326	198	157	297	295
Ca(7.6-12.0)	7	7.2	7.8	5.8	6.6
CREA(0.5-1.8)	1.6	1.3	1.2	1.1	1.4
Glu(70-143)	221	560	700	686	686
PHOS(2.5-6.8)	9.7	10.1	8	7.6	5
BUN(7-27)	109	107	107	105	102

nary cardiac surgeon has used hypothermic condition at 25-30ºC (6,8,17). The advantage of hypothermic condition is the reduction in metabolism that can be decreased the flow rate from 100 ml/kg/min to 30 ml/kg/min with deep hypothermia at 18-20ºC (10). Under the hypothermic condition, it allows lower flow rates, less physiological trauma, better myocardial protection (10). There are three approaches to hypothermia under CPB: blood-cooling, cold cardioplegic perfusion, and surface hypothermia. In this case, blood-cooling and cold cardioplegic coronary perfusion was used for hypothermic condition. The temperature was maintained around 27ºC. However, the hypothermia can make several risk factors on the management of bypass (11). PO2 and PCO2 can be higher during and after CPB due to severely affected respiratory function undergoing hypothermic condition (11,19). In addition, slow cooling and quick re-warming technique is the key for a successful management. In this case, the level of PCO2 was higher, while PO2 was lower during CPB (Table 1). PCO2 level was too much low and PO2 level was too much high compared with normal reference range. This means the patient oxygenation and gas exchange was not sufficient so that the patient was taken severe acidosis. When the postoperative pH level was compared the pH level during CPB, it was revealed (Table 2). SpO2 was also kept lower than normal level (Fig 3). It was possible that the severe acidosis situation was one of the main reasons for the dog death. Inadvertent hypothermia control in open-heart surgery can induce adverse physiologic effects including cardiac arrhythmias, impaired hemostasis, and disorder of total body oxygen consumption. Moreover anemia, arrhythmia, bleeding, and myocardial ischemia during and after cardiac surgery can be aggravated by hypothermic situation (11,19). It has been studied that quadruple mortality rates are higher in human patients who remain hypothermic 2 hours after surgery (11).

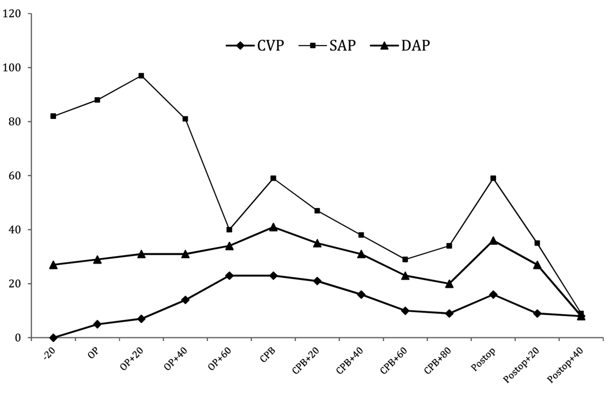

Fig 2. Change with time of blood pressure.

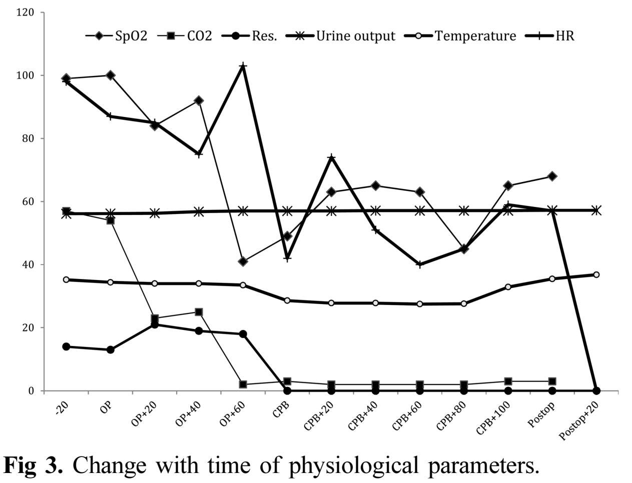

Fig 3. Change with time of physiological parameters.

Table 3. Electrolyte analysis

	Pre-op	OP	CPB	Postop	Postop+30	Postop+60
Na(144-160)	137.5	149	139	124	131	134
K(3.5-5.8)	3.4	1.7	4.6	5.1	4.9	5.4
Cl(109-122)	103.6	108	97	104	105	107

During open-heart surgery, many other organ systems can be affected as well. The important impairments are renal insufficiency, neurological problem, gastrointestinal disease, and immune suppression (9,19). In this case, blood analysis was taken by every 20 minutes for examination of organ condition (Table 2). The levels of albumin, alkaline phosphatase (ALP), alanine transaminase (ALT), amylase (AMY), calcium (Ca), creatinine, and phosphorus were no found a specific impairment during operation except a fluctuation during bypass period. However, glucose and blood urea nitrogen (BUN) were highly examined. During CPB, usually glucose level needs to be kept highly because of supplement of body energy and acceleration of urine output (11). BUN level was still high from initial visiting due to renal failure.

Hemorrhage related to cardiac surgery is also critical factor for patient recovery (9). Bleeding or hemorrhage induces hypotension and releases inflammatory mediators. As blood is circulated into whole circulation tube for bypass, heparinization is needed to prevent coagulation from blood. At another aspect, hemorrhage can result from heparinization from venotomy and atriotomy sites (9,11). In this case, severe bleeding was not happened and two suction lines were connected with CPB circuit by roller pump. When hemorrhage was occurred at surgical area, the bleeding was sucked into reservoir. Hypotension was a critical problem for the patient. Although some inotropic agents were taken to the dog, arterial blood pressure was not increased (Fig 2). Low cardiac output syndrome (LCOS) is a clinical accident that is caused by a transient decrease in systemic perfusion secondary to myocardial dysfunction (11). LCOS is observed commonly in patients after cardiac surgery. The outcome induces metabolic acidosis by imbalance between oxygen delivery and oxygen consumption (11). It was thought the dog might have LCOS by the evidence of low pressure and low cardiac output. LOCS was one of the causes of the patient death. Electrolyte & acid-base balance are important factors to check patients with cardiac surgery (9). After cardiothoracic operation, usually patients have hypokalemia, respiratory acidosis and metabolic acidosis (11). In this case, the electrolyte including Na, Cl, and K was normally maintained during the period of whole operation (Table 3). Although metabolic and respiratory acidosis was remarkably found, the acidosis was also controlled by supplement of sodium bicarbonate.

Immune and systemic inflammatory response is typically associated with CPB. Contact of blood with artificial surface of the CPB circuit and hypoperfusion of organ aggravate the inflammatory response (11). This response is characterized by contact of neutrophils, monocytes, complement, and cytokines and caused a pathological state of inflammation, vascular permeability, and coagulopathy (19). Systemic inflammatory response is induced in all patients with CPB. Although the severity of the response is variable, the length of CPB is frequently related to clinical sequel (11). In this case, the period of CPB was 100 minutes as a suitable time for the dog and antibiotic was given to prevent any infection during the whole operation.

In conclusion, the main causes associated with failure of cardiac surgery include CPB management, hypothermia, organ dysfunction, hemorrhage, hypotension, electrolyte & acid base imbalance, and infection as stated above. In this case, the dog might be died from the failure of oxygenation and gas exchange by hypothermia and serious hypotension with low heart rate by LCOS. Through the several considerations from this case, it is known that coming cardiac surgery for mitral valve repair is required to be more careful for successful operation. Further it can be brought to increase success rate in further operation.

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심한 이첨판 역류를 가진 개에 실시한 이첨판 성형술의 실패 원인

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요 약 : 10살령의 4 kg 암컷 치와와가 심한 울혈성심부전의 수술적 치료를 위해서 내원하였다. 여러 가지 진단을 통해 이 환자는 심한 이첨판 폐쇄부전과 중등도의 삼천판 폐쇄부전이 확인되었다. 약물에 대한 치료적인 반응이 여의치 않아, 수술적으로 이첨판을 교정하는 치료방법으로 지시되었다. 체외순환을 이용한 심폐순환기하에서 이첨판교정술이 실시되었다. 하지만 이 환자는 교정 후에 마취에서 회복되지 못하고 사망하였다. 심장수술에 있어 실패를 유발하는 여러 가지 원인들에는 심폐순환기 운용, 저체온증, 장기부전, 출혈, 저혈압, 전해질과 산-염기 불균형, 그리고 감염 등이 있다. 비록 이 환자는 사망하였지만, 그 원인을 밝혀 내는 일은 수의학 분야에서 중요한 일이다. 이 증례의 사망원인을 고찰해 본 결과, 심한 저체온증에 의한 가스환기와 산소공급의 이상 그리고 심장수술과 관련한 저심박출량 증후군으로 인한 낮은 심박동수를 동반한 저혈압으로 사망한 것으로 생각되었다. 이 증례의 원인 규명을 위한 고찰은 이첨판성형술의 성공을 위해서는 좀더 세심한 주의가 요구됨을 알 수 있게 해주었고, 나아가 앞으로의 수술에서 성공률을 높일 수 있는 중요한 계기가 될 것이다.

주요어 : 이첨판 폐쇄부전, 이첨판 성형술, 심폐순환, 위험인자, 개