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Original Research Article

Peripheral Nerve Injuries Following Cardiac Surgery: A Neglected Side Effect

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Abstract: In recent years, peripheral nerve injury is a relatively few complication after cardiac surgery. We investigated that peripheral nerve injuries were retrospectively assessed in the results of the patients who underwent open heart surgery during a 36-month period. Peripheral nerve injuries was reported in 11 cases (1.9%) of 581 patients who underwent correction of congenital heart surgery, valve operation and coronary artery bypass grafting with median sternotomy. The main symptoms were continuous pain, and motor and sensory disturbances at the affected upper or lower extremity. The majority of patients recovered without further treatment. This article introduces the basic anatomy and physiology of peripheral nerves and nerve injuries. A clear understanding of these mechanisms is important in order to modify surgical and nursing managements to prevent this neglected complication of cardiac surgery.
Keywords: Complications; Nerve damage;Peripheral nerve; Cardiac surgery

INTRODUCTION

One of the most common complication after cardiac surgery is neurological complications. Manystudies and attentionhave been focused onthese neurologic(such asstroke, delirium, and cognitivedysfunction) ,which represent only the centralnervous system abnormalities that occur in thesetting[1] . Although therewere some studies in the past, those studies have been a few, and most references to such problems were directed towards single peripheral neuropathy, such as recurrent laryngeal nerve, vagus nerve, brachial plexus neuropathy, etc. Over the past 36 months, at affiliated hospital of Guilin Medical University, we collected11 patients with peripheral neuropathies after cardiac surgery. The aim of this study was to surveyclinical characters and outcomes in such cases subsequent to a variety of cardiac surgical proceduresat our hospital.

PATIENTS and METHODS

The local ethical committee approved the current analysis as part of regular quality control. The study sample was drawn from a consecutive series of patients undergoing open heart surgery during a 36-month period. To allow for direct comparisons and assessment of these complications, only patients in whom at least two physicians diagnosed as peripheral neuropathy were considered for analysis. A single surgeon or nursewould contact all patients at least 3 times for follow up on the telephone. Patients who were not reached or unable to individually and adequately answer the series of questions were excluded from the analysis. No other exclusion criteria applied.

Clinical data were collected from a prospectively maintained and comprehensive database, which collects a conventional range of preoperative, operative and post-operative information. All patients' data were checked for plausibility and corrected. Main outcome information was collected from the scripted interviews: as mentioned, assessment focused on the patient's own perception of the local situation. Information regarding perioperative data was categorized (Table-1).

Table 1: The clinical character of the patients with peripheral nerve injury

	Age(year)	Sex	Incision	Procedure	Operation time(min)	Time interval(day)	Type of nerve damage
Case 1	56	M	Median sternotomy	CABG	153	7	Brachial plexus
Case 2	31	M	Median sternotomy	DVR	241	5	Brachial plexus
Case 3	56	F	Median sternotomy	FET arch repair	288	7	Recurrent laryngeal nerve
Case 4	48	M	Median sternotomy	FET arch repair	354	4	Recurrent laryngeal nerve
Case 5	62	F	Median sternotomy	Off pump CABG	156	6	Saphenous nerve
Case 6	65	M	Median sternotomy	CABG	187	9	Saphenous nerve
Case 7	52	F	Median sternotomy	CABG	289	6	Saphenous nerve
Case 8	48	F	Median sternotomy	DVR	289	8	peroneal nerve
Case 9	51	F	Median sternotomy	Redo-MVR	355	11	peroneal nerve
Case 10	42	F	Median sternotomy	CABG	148	5	peroneal nerve
Case 11	1	F	Median sternotomy	TOF	327	6	phrenic nerve

CABG:Coronary artery bypass, DVR:double valve replacement, FET:frozen elephant trunk, MVR: mitral valve replacement, TOF: Tetralogy of Fallot

RESULT

The main symptoms were continuous pain, and motor and sensory disturbances at the affected upper or lower extremity. The majority of patients recovered without further treatment. Only one patient with peroneal nerve injury reported that she was incomplete recovery and felt her left foot dropping with weakness.

Table 2. The outcome of the patients with peripheral nerve injury

	Type of nerve damage	Clinical manifestations	Treatment	Recovery time(month)	Outcome
Case 1	Brachial plexus	Pain, motor and sensorial disturbances developed at the left upper extremity	functional exercise and physiotherapy	8	Full recovery
Case 2	Brachial plexus	Pain, motor developed at the leftupper extremity	functional exercise physiotherapy	6	Full recovery
Case 3	Recurrent laryngeal nerve	Vocal cord dysfunction	physiotherapy	11	Full recovery
Case 4	Recurrent laryngeal nerve	Vocal cord dysfunction	physiotherapy	15	Full recovery
Case 5	Saphenous nerve	Paresthesia in the affected limb after surgery.	physiotherapy	13	Full recovery
Case 6	Saphenous nerve	Paresthesia in the affected limb after surgery.	physiotherapy	7	Full recovery
Case 7	Saphenous nerve	Neuropathy dermatitis at the site of operational incision	physiotherapy	11	Full recovery
Case 8	peroneal nerve	Left foot drop with weakness of dorsiflexion and eversion.	physiotherapy	5	Full recovery
Case 9	peroneal nerve	Left foot drop with weakness of dorsiflexion and eversion.	physiotherapy	3	Partial recovery
Case 10	peroneal nerve	Bilateralfoot drop with weakness of dorsiflexion and eversion.	physiotherapy	6	Full recovery
Case 11	phrenic nerve	postoperative bilateral diaphragm paralysis and difficult extubation	bilateral diaphragmatic placation	15 days	Full recovery

DISCUSSION

The perioperative peripheral neuropathies are infrequent but potentially debilitating complications in surgical patients [2]. Theperioperative peripheral nerve injury canbe a result of a variety of factors. It is believed that such injuries can be associated with patient positioning, comorbidities, and surgical conditions[3].

The peripheral neuropathies in cardiac surgery including the brachial plexus, phrenic nerve, recurrent laryngeal nerve, other peripheral nerves, as well as thevisual pathways, also occur with variable incidenceafter cardiac surgery[4]. The most likely pathologic mechanisms of injury include local compression, stretch, ischemia and metabolic abnormalities. These complicationsvary from the mild to the more serious and debilitating outcome.Because of the seriousness and complexitiesof events in the perioperative period during cardiacsurgery, these more subtle injuries are oftenoverlooked by both cardiac surgeons and nurses.

In cardiac surgery, different mechanisms (hypothermic and mechanical) of phrenic nerve injury have been fully recognized. Important anatomic relationships between the phrenic nerves and structures in the thorax play a major role in this kind of nerve injury during cardiac surgery. Phrenic nerve injury is more frequent on the left sidethan on the right side. The diaphragmatic dysfunction due to phrenic nerve injuryis a complication that is also fully understood. It can lead into a disabling consequences, especially inhigh risk populations such as childrenand patients withchronic obstructive airway disease[5]. Phrenic nervehas intimate anatomic relation to the pericardium, which makes it vulnerable to freezing injury during hypothermicmyocardial protection using ice slush. In our cases, the patients who were managed with a placation had surgery earlier, were significantly receiving mechanical ventilation at the intensive care unitat the time of initial diagnosis. Diaphragmatic placation should be a good choice, especially in small children, to wean patients from mechanical ventilation and to prevent long-term side effects of mechanical ventilation. Also during coronary artery bypass, theinternal mammary arteries are very close to the phrenic nerve, which makes the nerve vulnerable to injury. To a cardiac surgeon, a clear understanding of these mechanism is necessary in order to modify usual surgical techniquesto prevent damage to the phrenic nerves [6].

Brachial plexus have some principal anatomical characters that make the brachial plexus susceptible to injury in cardiac surgery. Brachial plexus injury may occur without obvious cause in patients undergoing cardiac surgery. Positioning of the patient with ‘hands up’ positioning could significantlyreduce the incidenceof brachial plexus injuries. Furthermore, Sternal retraction is one of the important factors responsible for brachial plexus injury. How wide the retractor is opened for internal mammary arteryharvesting are also important factors in quantifying risk of postoperativebrachial plexus neuropathy. Wider sternal retraction and longer bypass timedid increase the risk of developing postoperative neuropathy. Some studies demonstrates theDelacroix–Chevalier to be the safest[7]. We admitted that median sternotomy risks brachial plexus injury and where possible thesternum should be opened as small a distance as possible with symmetrical retractor and using a caudally placed retractor [8].

The left recurrent laryngeal nerve, due to its close relation to the aortic arch, left lung apex, esophagus, trachea, mediastinal lymph nodes and left pulmonary artery, is particularly vulnerable to lesions[9]. Recurrent laryngeal nerve can be damaged during internal mammary artery dissection, endotracheal intubation, use of transesophageal echocardiography probe. Recurrent laryngeal nerve injuries also occur in surgery affecting the convexity of the aorticarch. In our cases, two patients who underwent frozen elephant trunk stent surgery were confirm the diagnosis of left recurrent laryngeal nerve injury. The damage to the left recurrent laryngeal nerve or its branches may be avoided only by identification and careful exposure of the nerve itself. An experienced surgeon with good knowledge of the anatomy of the laryngeal nerve injury and its anatomical variations is required for aortic arch surgery[10]. Aortic procedures and prolonged operation increase the risk of vocal cord dysfunction. Severe vocal cord dysfunction tended to be associated with aortic surgery and prolonged intubation [11]. The diagnosis of laryngeal nerve injury could be confirmed by using laryngoscopy. Most patients could be treated conservatively.

In coronary artery bypass surgery,the long saphenous vein is still the most popular graftmaterial, despite the increase in theuse of the internal mammary artery[12]. The saphenous nerve becomes superficial in the leg and may give an articular branch to the medial side of the knee joint. After coronary artery bypass surgery,some patients experience sensory deficits around theankle and leg, such as pain, anesthesia, and hyperesthesia.These are due to various degrees of injury to thelong saphenous nerve, which lies in close proximity tothe vein below the knee.It then descends with the longsaphenous vein towards the medial malleolus. Injury to thesaphenous nerve and its branches results in most of thepostoperative sensory abnormalities in the leg. The saphenous nerveinjury may occur at operation as a result of surgicalhandling or trauma or postoperatively from compression [13]. Risk factors identified in this trial are age, female gender, higher body mass index, diabetes mellitus, distal-to-proximal dissection of the GSV, and closure of the leg wound in two layers[14]. ButBudillonand his

colleagues demonstrates that saphenous neuralgia after harvesting is a rare complication. The main symptom is anesthesia but its duration is generally no longer than 2 months. Pain and hyperesthesia for the early onset and the early disappearance, are considered as a normal consequence of surgical procedure[15]. In our cases, the saphenous nerve injuries were also occurred, which reminds us to pay attention to this problem.

In operation room, theprolongedand incorrect support of thefibular head on a hard surface can led toperoneal nerve compression.Compression or stretching resulting in ischemia has been thought to be the main cause of peripheral nerve injury. Acute weakness of foot elevation can have different etiologies. Clinical examination does not always allow a clear differentiation.The electrophysiological examination is often required for diagnosis and localizing the injured nerve lesion.In our cases, the area of the fibular head where the nerve runs superficially was the site of injury due to its anatomy and superficial course. The prolonged cardiac bypass time and not smooth recovery post operationmay have contributed to the nerve injury. Setty and his colleague have shown that low body weight and leg malpositioning were associated with the peroneal nerve injury[16]. Our patients were all very thin, and this would have been an additional risk factor.The duration of the o has a direct correlation to the postoperative neuropathy, especially after the cardio-thoracic surgery with neuropathy being remote from operative sites. Increased procedure duration causes prolonged periods of nerve compression and hypoperfusion, which increase the risk for development of neuropathy. In our case, prolonged duration of surgery may have a causative role for the nerve injury.

Early diagnosis and physiotherapeutic treatment were crucial for the patients withperipheral nerve injuries.The patient should be assessed, including a full history and examination. Physical findings must be well documented and neurologist early investigationshould be guaranteed. An experienced neurologist can usually distinguish between many peripheral nervepathy. Investigations include electromyography and nerve conduction studies.Electromyography involves examination of muscle activity at rest and during movement. Electromyography provides useful information about the nerve supply to a muscle [17]. These tests are performed by a neurophysiologist and are interpreted in relation to the clinical history. Progressive or severe peripheral nerve injuries needs urgent neurologist assessment and immediateintervention.The timing of electrophysiology studies is important in obtaining an accurate diagnosis.Nerve conduction studies involve stimulation of sensory or motor nerves and recording of propagated action potentials. 14 daysor more may be required for the process of nerve degeneration to be completed. For this reason it isoften recommended to have electrophysiology studies done several weeks after the onset of symptomsto avoid falsely reassuring assessment.Electrophysiology studies can also be used to monitor nerve injury recovery over time.

In most cases, peripheral nerve injuriesresolve within 6-12 weeks [18]. More than half of patients typically regain full motor and sensory function within one year. Patients with poor recovery can have permanent or ongoing symptoms. Permanent injury may be minor (such as small area of sensory loss that isminimally inconvenient to the patient), or major and disabling (such as significant upper or lower limb movement disorder andchronic pain). Poor recovery can have a profound bad impact on quality of life for patients with ongoingnerve injury.Nerve injuries have the potential to cause substantialmorbidity after cardiac surgical procedures.For the most cases, these injuries are preventable,provided that the cardiac surgeon and nurse have a deep understandingof the relevant anatomy and followsimportant surgical principles. Whenperipheral nerve injuriesdo occur, it is important for the surgeon and nurse to recognizethe solutions available in the immediate andpostoperative settings, including immediate nerve reconstruction andrehabilitation procedures to improve the outcomesof loss of the damaged nerve's function.

Peripheral nerve injury after cardiac surgery often feels likea technical failure to surgeon and patient alike. Fora cardiac surgeon, there is the knowledge that the relevantanatomy was misidentified or poor surgicaltechnique was used and a preventable error resulted. Progresshas been made in the field of nerve repair andregeneration; prompt identification and appropriatemanagement can significantly mitigate themorbidity of nerve injuries. But, for the patient, there is temporary or lasting functional deficit that may result in substantial morbidity and decrease quality of life. The surgeonshould be mindful that there is no current remedyfor these injuries that is as reliable as avoidance.Further prospective research are warranted to better understand the risk factors associated with and managements for prevention of this potentially threatening complication.

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