Myocardial injury after temporary transvenous cardiac pacing

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Abstract

Introduction: It is not unusual for temporary transvenous cardiac pacing (TVCP) leads to penetrate and occasionally perforate the right ventricular wall, which generally is asymptomatic. The definition of myocardial injury is evidence of elevated cardiac troponin (cTn) values above the 99th percentile upper reference limit (URL). Myocardial injury is associated with an adverse prognosis. The present study was designed to evaluating myocardial injury complicated by TVCP. Methods: Retrospective study from August 2018 to March 2020, 33 consecutive patients undergo elective TVCP support for non-cardiac procedures, 22 of them had cardiac biomarkers assays before and after TVCP. These 22 eligible patients had a median age of 66 (50-83) years, 6 (27.3%) were women, and all baseline cTn <1 URL. Compare cardiac biomarkers before and after TVCP. Results: 20 (91%, N=22) patients detect cTn >1 URL after pacing. Paired t-test compare before and after pacing leads insertion showed a mean cTn elevation of 3.599 (95% CI, 1.566 to 5.632, P<0.01)URL, and no significantly creatine kinase-MB elevation of 0.1550 (95% CI, -0.01239 to 0.3224, P>0.05) URL. Conclusion: This study demonstrates a high incidence of substantial myocardial injury by TVCP, which should be concerned.

Myocardial injury after temporary transvenous cardiac pacing

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Keywords: Temporary pacemaker; Temporary transvenous cardiac pacing; Myocardial injury; Bradyarrhythmia; Perioperative myocardial injury.

Abstract

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Methods: Retrospective study from August 2018 to March 2020, 33 consecutive patients undergo elective TVCP support for non-cardiac procedures, 22 of them had cardiac biomarkers assays before and after TVCP. These 22 eligible patients had a median age of 66 (50-83) years, 6 (27.3%) were women, and all baseline cTn <1 URL. Compare cardiac biomarkers before and after TVCP.

Results: 20 (91%, N=22) patients detect cTn >1 URL after pacing. Paired t-test compare before and after pacing leads insertion showed a mean cTn elevation of 3.599 (95% CI, 1.566 to 5.632, P<0.01)URL, and no significantly creatine kinase-MB elevation of 0.1550 (95% CI, -0.01239 to 0.3224, P>0.05) URL.

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Introduction:

Temporary transvenous cardiac pacing(TVCP)is a reliable heart rate control and potentially life-saving intervention. Primary indication is life-threatening bradyarrhythmia with hemodynamic compromise, include bradyarrhythmia due to atrioventricular blocks or sinus node dysfunction. Other indications include tachyarrhythmias needing overdrive pacing, and dysrhythmias needing rate support to allow the use of medications directed toward treatment of tachyarrhythmias that might exacerbate bradycardia such as beta blockers.[1, 2]

Complications can be considered in two broad categories: relate to the venous access or relate to pacing catheter.[3] The use of ultrasound guidance result in safer venous access, and the complication rate is statistically insignificant between novice and experienced clinicians.[4]Central venous access–associated complications were rare when venous access was obtained with ultrasound guidance.[5-7]Complications or concerns relate to pacing catheters also can be divided into two categories: electrical performance and mechanical effects.[2] Electrical performance requires proper catheter placement, the lead stability, firm connections to the external generator, and external generator management to achieve pacing function. But mechanical effects are adverse complications.

The TVCP lead is relatively stiff, promotes ventricular ectopic activity, or ventricular tachycardia during catheter insertion is common and occasionally prolonged ventricular arrhythmias.[8] It is not unusual for these leads to penetrate and occasionally perforate the right ventricular wall.[2] This is usually manifest by raised pacing thresholds and occasionally by pericarditic pain and a pericardial friction rub.[9] Rarely this will result in cardiac tamponade which associated with increase in risk for in-hospital death[10]. Pericardial tamponade, perforate or penetrate the ventricular wall are literally myocardial injuries. The term myocardial injury used nowadays is when there is evidence of elevated cardiac troponin (cTn) values with at least one value above the 99th percentile upper reference limit (URL).[11] Myocardial injury is associated with an adverse prognosis.[12, 13] However, there is no study evaluating myocardial injury complicated with TVCP by cTn assays. Therefore, the objective of this study was to investigate myocardial injury caused by TVCP.

Methods:

Study design and patients

Retrospect study consecutive 33 cases/patients undergo elective TVCP placed by the first author (Meng L) for scheduled non-cardiac surgery from August 2018 to March 2020. 22 of them have measured cardiac biomarkers values before and after TVCP placement. Analysis of the values changes of the cardiac biomarkers. The Hunan Provincial People's Hospital Ethics Committee granted study approval (reference number: 2020-07) and waived the usual requirement for informed consent as all data were de-identified and analyzed anonymously.

22 eligible patients had a median age of 66 (50-83) years, and 6 (27%) were women, 13 (59%) from the cancer center, others from hepatobiliary surgery, general surgery, and spine surgery department. None of the patients had history recorded of myocardial infarction, stroke, heart failure, chronic kidney disease, anemia. No remarkable structure abnormality findings in echocardiography. B-type natriuretic peptide (BNP) and hemoglobin were normal. Except for slightly elevated creatinine in 1 case (120.5umol/L), creatinine was normal. Decisions of TVCP were made by surgeons after consultation with cardiologists or/and anesthesiologists. Except for the bradyarrhythmia, patients with low cardiovascular risk, so TVCP were simply placed bedside, rather than catheter lab. TVCP indications and baseline characteristics of patients included in table 1.

Table 1. Baseline characteristics of patients and indication of temporary transvenous pacing.

Characteristic	All(N=22)	
Age,y	55-83 (median 66)	
Female	6 (27.3%)	
Hypertension	3 (13.6%)	
Diabetes mellitus	3 (13.6%)	
Coronary artery disease	1 (4.5%)	
Smoking	8 (36.4%)	
Surgery type	Tumor ectomy 13 (59.1%)	
	Bile duct stones 4 (18.2%)	
	Spine diseases 3 (13.6)	
	Intestinal obstruction 1 (4.5%)	
	Hernia 1 (4.5%)	
Indication	Mobitz type II AVB 1 (4.5%)	
	Sinus pause 1 (4.5%)	
	Sinus bradycardia and	Junctional rhythm 1 (4.5%)
		SVT/AT 2 (9.1%)
		1°AVB & CRBBB 1 (4.5%)
		High risk intraoperative bradycardia 12(54.5%)
		Absent response to atropine test 4 (18.2%)

Caption of table 1: Sinus bradycardia: Sinus rate <50 bpm; AVB, atrioventricular block; CRBBB, complete right bundle branch block; SVT: supraventricular tachycardia; AT: atrial tachycardia.

TVCP catheter was placed within 12 hours before surgery. The catheter placed from 6 to 24 hours, and withdraw soon after surgery in 21 cases, placed 3 days in 1 case. Cardiac biomarkers values were measured within 2 weeks before TVCP and at night (2) or next morning (20) after surgery.

2, Material and temporary pacemaker placement

Material

Medtronic, model 5348 or 5392 temporary pacemaker. 7 French (F) hemostasis introducer (Fast-Cath™ & Cath-Lock™, ST. JUDE MEDICAL) and 6 F non-floating right heart curve bipolar pacing catheter (PACEL™, ST. JUDE MEDICAL). Catheter tip has two electrodes, which are about 1 cm apart. The distal tip is a negative and active electrode, and the proximal electrode is positive and indifferent.

Bedside temporary pacemaker placement

The primary access site was through the right internal jugular vein (16 cases, 73%), followed by subclavian vein (4 cases, 18%) when surgery involved the right neck. The femoral vein approach was used (2 cases, 9%) after difficulty was experienced in advancing TVCP catheter through the subclavian vein or right internal jugular vein site. Except for subclavian vein access, all central venous access was under ultrasound guidance.

Pacing catheterization guided by bipolar (both proximal electrode and distal electrode connect to separate V lead) intracavity electrocardiography (IC-ECG).[14, 15]The bipolar IC-ECG monitoring plus direction control skill of the catheter tip made bedside TVCP catheter placement feasible and 'visible'.[14]Target proximal electrode IC-ECG was slightly ST-segment elevation <2 mV which constitute a proper position against the ventricular wall and adequate pacing site,[16] but it is impossible to maintain it if patient change positions (Fig 1). All placement was further confirmed by following standard 6-lead pacing ECG that II, III, and aVF QRS waves downward.

Figure 1. Unstable pacing lead.

Caption of Fig 1: Access site was through the right jugular vein. Patient laid flat and turned head to left in the implantation process, and ST segment in proximal electrode IC-ECG would elevate when head turn to right or turn up with pillow.

The sensing threshold ranges from 2.5mV to 20mV (utmost setting at pacemaker), with an average of 7.34 mV. The pacing threshold was 2 mA in one case, others no more than 1 mA, with an average of 0.72 mA. The pulse width is 1.5 ms and not programmable. Pacemaker setting was set to VVI mode, Rate 40 to 60 ppm, Sense 1.5 to 3 mV, Output 2-8 mA. Anesthesiologists have been told the best tact was maintain sinus rhythm, and pacing rate could adjust as their need. No case reported shock or low blood pressure.

Complications

Complications were rare. In one case, the test pacing at 80 ppm, the patient felt uncomfortable. Arterial puncture happened in 2 cases, but do not need special intervention, including one hematoma of thorax caused by a subclavian arterial puncture. Ventricular ectopic beat and ventricular tachycardia are common when pacing catheter explores in the right ventricle chamber to achieve STEMI pattern. These will be resolved once the manipulation of the lead has ceased. Other complications, such as thromboembolism, infection, bleeding, were not reported.

Statistical Analysis

The data was analyzed for the plasma concentrations of cardiac biomarkers, high sense cardiac troponin (cTn), creatine kinase MB isoform (CK-MB), creatine kinase (CK) and myoglobin (MYO). cTn assays (N=44) include 9 cTnT and 35 cTnI values. Measure unit was uniformed by upper reference limit (URL). Myocardia injury, CK-MB above URL were calculated. Paired t-test was applied to compare the four biomarkers values before and after TVCP. Statistical significance for all analyses was $P<0.05$. Analyses were conducted using GraphPad Prism 5.

Result

All cases (N=22),myocardial injury detected in 20 (91%): before operation cTn values are normal,after operation 20 (91%) above URL. Before operation 1 (4.5%) CK-MB value above URL, after operation 4 (18%) values above URL.

There were statistically significant differences in the comparisons of serum cTn and MYO level before the operation and after operation: cTn mean of differences 3.599 (95% CI, 1.566 to 5.632), P=0.0014; MYO Mean of differences 2.139 (95% CI, 0.8034 to 3.475), P=0.0032. There were no statistically significant differences in the comparisons of serum CK-MB and CK level before the operation and after operation: CK-MB mean of differences 0.1550 (95% CI, -0.01239 to 0.3224), P=0.0677; CK mean of differences 1.080 (95% CI, -0.4072 to 2.568), P=0.1458. (Fig 2 and Table 2)

Figure 2. Comparisons of cTn, CK-MB, CK, MYO before and after operation.

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image2.emf available at https://authorea.com/users/320654/articles/450139-myocardial-injury-after-temporary-transvenous-cardiac-pacing

Table 2. Myocardial biomarkers before and after operation.

	CTn	CK-MB	CK	MYO
Before operation	**0.30±0.045**	**0.49±0.067**	**1.0±0.56**	**0.99±0.43**
After operation	**3.9±0.97**	**0.65±0.075**	**2.1±0.53**	**3.1±0.68**

Discussion

Though no strict serial sequential assays, the myocardial injury was identified in 20 (91%) of 22 after TVCP. Average increased 3.599 URL cTn indicates substantial cardiac injury. Before cTn assay and term of myocardial injury, the best myocardial infarction biomarker was CK-MB. CK-MB slightly above URL in only 4 (18%) of 22, and average increased 0.1550 URL without statistically significant or clinic meaning. This may be why a high incidence of myocardial injury after TVCP was not noticed. Elevation CK and MYO values could attribute to perioperative non-cardiac muscle injury. Patients requiring emergency TVCP usually have an acute heart condition such as myocardial infarction, heart failure, cardiogenic shock, cardiac arrest[10], and subsequently with the elevation of cTn values. Postoperative cTn levels are elevated after all types of cardiac surgery**[17]**, so it is a predictable elevation of cTn values for patients requiring TVCP to support cardiac surgery. In this study, elective TVCP was scheduled for non-cardiac surgery. So, patients were well prepared and relatively healthy. Risks of myocardial injury include hypoxemia, shock/hypotension, anemia, kidney disease, heart failure, ischemic heart disease[11], but none of them recorded in those 22 cases. And baseline cTn values under URL, normal BNP, all of those limit the incidence of perioperative myocardial injury and reveal myocardial injury by TVCP. Hence, myocardial injury complicated with TVCP was an under-estimate complication.

Constant friction between the catheter tip and the ventricle wall could explain the myocardial injury. Cardiac perforation is an extreme example of mechanical damage. For permanent pacing lead, giant R wave on IC-ECG stands for continuous contact between electrode and ventricle wall. QS wave and lightly ST elevation on IC-ECG recommend for TVCP catheter,[16], which indicate catheter tip is not continued touch with the ventricular wall. Since the heart systole and diastole constantly, there was a constant collision between the catheter tip and endocardium. Suppose heart rate 60 beats per minute, 86400 impacts happened in one day. Unlike permanent pacing lead fix to one spot, TVCP catheter tip may contact and injury a certain surface of endocardium.

The indication of TVCP must weigh the risks and benefits. Our study would aid in clinical decision-making to guide practice in their diagnosis, evaluation, and management. TVCP catheter is not just a foreign body to the heart, and the substantial cardiac injury should be a concern in TVCP placement. Myocardial injury is prognostically important and warrants clinical attention.[18] Thought underlying pathophysiological mechanisms of myocardial injury after TVCP is different from the more common reason such as myocardial infarction, shock, poison, myocarditis; it contributes to a poorer outcome more or less. The complication rate of TVCP is 22.9% in the last 10 years, of which 10.2% is considered serious.[3] The most common serious complication is re-intervention (5.4%), followed by cardiac perforation (1.6%).[3]Generally, perforations are asymptomatic,[19, 20] usually seal on their own without causing any significant morbidity.[16] An Analysis of $>$ 360,000 Patients underwent TVCP in the United States between 2004 and 2014, concludes TVCP is generally safe with low pericardial complication rates (0.6%), which is a fivefold increase in risk for in-hospital death.[10] But the in-hospital mortality rate was >10% and striking high mortality rate >50% over 4 years of follow-up, raise the concern to seek other complications and alteration of TVCP.[3, 10, 21] Though the high mortality indicate a sick patient population, myocardial injury which is associated with an adverse prognosis[12, 13] should be a concern. Hwang etc. evaluated the clinical differences between patients who have undergone TVCP and patients who have not. In their report, in acute inferior ST-elevation myocardial

infarction and high-degree atrioventricular block, periprocedural TVCP in primary percutaneous coronary intervention do not decrease adverse cardiocerebrovascular events, but more likely increase cardiogenic shock and prolonged hospitalization.[22] Myocardial injury may explain their result. High incidence of myocardial injury further support the guidelines recommendation that TVCP should be avoided or applied as briefly as possible,[23] it may be best for the patient to avoid temporary pacing and proceed directly to permanent system implantation.[1] It is a graded increase of major adverse cardiovascular events and mortality with higher postoperative cTn levels.[24, 25] cTn release from the contractile apparatus of myocardial cells, average elevation in our study was 3.599 URL, indicate small amount injury of myocardial cells.[11] cTn is not relate to endocardium, but endocardium is between contractile muscle and TVCP catheter. Since TVCP catheter tip do not fixed at one spot, endocardium damage would be broad. Consequence of large area endocardium damage, such as aggregation of platelets and the formation of thrombosis, ventricular arrhythmia should be the primary concern and worth further study.

This study has several limitations. First, it was conducted with a relatively small number of patients, resulting in an insufficient power to postulate generalizations. Second, myocardial injury cannot totally attribute to TVCP, since in patients with high cardiovascular risk, perioperative myocardial injury detected and quantified by an acute increase in high-sensitivity cTn plasma concentrations is a common complication after non-cardiac surgery occurring in 1 of 7 patients.[26] Third, this is not a prospected study, monitor cTn of the patients was clinicians' discretion; it is not consecutive series.

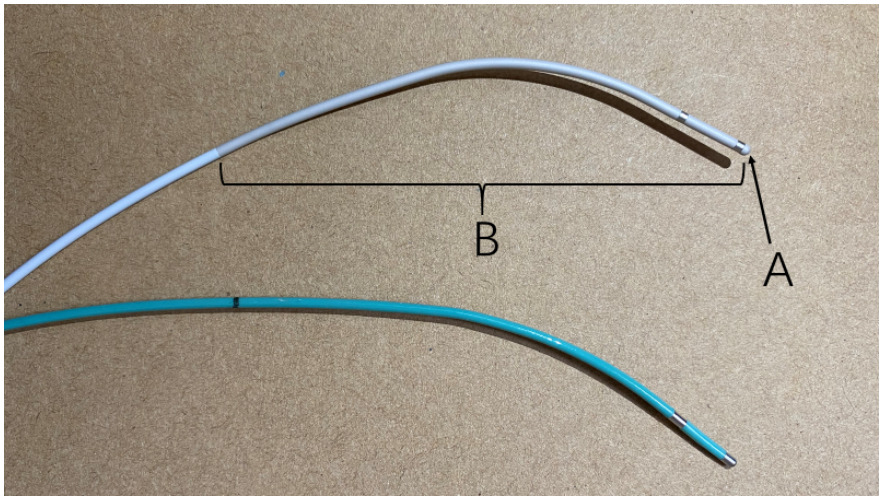
Option to mitigate myocardial injury

Active fixation temporary leads

Most current temporary leads as have a smooth, 5-6 F, isodiametric profile with no fixation mechanism; this is to enable stiff enough to prevent dislocation and easy removal. Newer active fixation temporary leads are available with a fixation screw; these are small diameter (3.5 F), soft tip, and remain easy to remove.[27] Its flexibility and fixation would moderate mechanical effects, so that reduce or avoid myocardial injury and cardiac irritation. Temporary-permanent transvenous pacing (TPPM) via a reusable permanent external generator attached to the active fixation temporary leads. TPPM is a safe procedure with rare direct complications,[28] and associated with a significantly lower rate of pacing-related adverse events and cost-effective (after 18 hours) as compared to the standard TVCP.[29, 30] Current guidelines recommend TPPM over TVCP for patients who require prolonged temporary transvenous pacing.[1]

Soft tip temporary leads

Figure 3. Soft tip catheter Vs traditional catheter.



Caption of Fig 3: Grey wire is a soft tip catheter; green wire is a traditional catheter used in this study. A, non-medal soft sphericity tip. B, 10 cm flexible distal part. Compare with current most used TVCP catheter, the grey catheter proximal part stiff as the same, while distal part more flexible.

While TPPM must operate under fluoroscope by a cardiologist with sufficient operator skills, which may not be available in an emergency or other reason, the TVCP catheter in this study has a smooth and stiff metal tip (the distal electrode). A soft tip design of TVCP catheter (Grey wire in Fig 3): proximal catheter as rigid as traditional TVCP catheter to keep operability, while soft sphericity tip and more flexible distal lead would prevent the catheter from penetrating the right ventricular wall which may cause pericardial tamponade, and lighten mechanical cardiac injury.

Conclusion

Although our study has several limitations, these results rise to the concern that TVCP catheter is more than a foreign body. With a high incidence of myocardial injury, clinicians should consider it in decision-making for TVCP indication, implantation.

Conflict of interest

None.

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