An Alternative Technique for Accurate Placement of Central Venous Catheter Tips

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For intravenous electrocardiography (IVECG), a wire stylet is usually utilized as the exploring probe to correctly position the central venous catheter. We present an alternative technique using the transduction probe connected to the original right arm lead of the ECG monitor to accurately position the central venous catheter. We compared the efficacy and quality of the IVECG signals of the two techniques. Sixty patients were randomly enrolled into two groups. In group G, the IVECG signal was conducted from the guide wire to identify the correct catheter tip position. In group T, the IVECG signal was conducted from the transduction probe to ascertain the tip position. The quality of IVECG signals, which included baseline drift, P-wave pattern, and QRS wave pattern, were assessed for 10 seconds. There was no obvious difference between the groups for catheter tip placement time or measured optimal catheter length. During manipulation, the incidence of cardiac dysrhythmia was higher in group G than in group T, but the difference was not significantly different (p = 0.09). Satisfactory IVECG signal quality was observed in 26 of the 30 patients in group G and in 27 of the 30 patients in group T. We conclude that the transduction probe can effectively conduct IVECG signals with no specific additional equipment required. It is an alternative technique for accurate placement of central venous catheter tips during IVECG.

Key Words: electrocardiographic signal, guide wire, transduction probe, central venous catheter

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Introduction

Central venous catheterization is necessary for monitoring central venous pressure, multiple fluid resuscitation, and administration of total parenteral nutrition or of antineoplastic medicines. Malposition or improper location of the catheter tip may cause vessel wall injury, vessel perforation, pericardial tamponade, thromboembolism, and increased incidence of malfunction of the venous access device [1–5]. In addition to the traditional methods of portable chest roentgenography or fluoroscopy to verify the accurate position of the catheter tip, the intravascular electrocardiographic (IVECG) technique is also a satisfactory alternative. It is a fast, safe, reliable, and cost-saving method to correctly position central venous catheter tips and reduce the incidence of exposure to radiation [6, 7].

For the IVECG technique to correctly place the central venous catheter tip, either electrolyte solutions or a wire stylet is utilized as the exploring ECG probe

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[8–10]. Nonetheless, obtaining the proper IVECG signals may require additional specific equipment such as a catheter-to-ECG adapter, alligator clamp, or a switch box. We present an alternative technique using the transduction probe connected to the original right arm lead of the ECG monitor. We compared the efficacy and quality of the IVECG signals of the two catheter tip placement methods.

Materials and Methods

Sixty patients with the American Society of Anesthesiologists physical status of I to III, aged 18 to 60 years who were scheduled to undergo abdominal elective surgery, were enrolled into this study and were allocated randomly into two groups. Those who suffered from atrial fibrillation, atrial flutter, or significantly uncorrectable arrhythmias were excluded from this study. This study was approved by the ethics committee of Kaohsiung Medical University and written informed consent was obtained from the patients.

The central venous catheter (Arrow®, Reading, PA, USA) was placed via the right internal jugular vein while patients were in the supine position under general anesthesia in the operating room. The introducer needle was inserted at the apex of the triangle formed by the sternal head and clavicle head of the sternocleidomastoid muscles and the clavicle. As the introduction syringe smoothly aspirated blood, a guide wire was passed through the syringe. The needle and syringe were removed over the wire and a double-lumen indwelling catheter was inserted over the guide wire, along the dilated passage, into the jugular vein.

The procedures to confirm the correct position of the catheter tip using the IVECG signal conducted by the guide wire (group G) was as follows. The indwelling catheter was pushed over the guide wire until the previously measured mark on the guide wire showed. The mark was measured to match the guide wire to the proper length of the indwelling catheter, to allow total exposure of the guide wire flexible J tip from the catheter, thus acting as the exposed probe. An adaptor (Certodyn®, B. Braun Melsungen AG, Germany) was connected to the guide wire by applying the clamp of the ECG connecting cable to change a normal two-limb-lead ECG to an IVECG. As the catheter tip was advanced toward the sinoatrial node, the p-wave increased in amplitude up to the point where the largest p-wave, or the wave as large, or larger than, the QRS complexes (p-atriale) was obtained. A biphasic p-wave was observed as the tip passed the sinoatrial node. The point of the largest p-wave, or p-atriale, was determined and the catheter was then withdrawn 3 cm. The length of catheter inserted and the IVECG quality were recorded. The electrocardiography monitors (Hewlett Packard, Model 66S, Boeblingen, Germany) were set to the monitoring mode, with a bandwidth of 0.5 to 40 Hz. The IVECG signals were recorded for 10 seconds. Another anesthesiologist who was unaware of the technique used to confirm correct catheter tip placement was assigned to assess the 10-second ECG strip for quality. The total scores were rated and categorized into four grades of excellent, good, fair, or poor (Table 1). The total scores corresponding to excellent or good were considered satisfactory.

The procedures to confirm the correct catheter tip position using the transduction probe to conduct IVECG signals (group T) was as follows. The transduction probe was introduced into the Luer lock injection cap connected to the distal pigtail orifice of the indwelling catheter. After flushing the catheter with 0.8 meq/mL $NaHCO_3$, a sterilized right arm electrode lead was attached directly to the non-coring transduction probe (Figure, A and B). The IVECG signals shown on the monitor were read and recorded in the same way as for group G. Side effects and complications that occurred during the procedures of placing catheter tips were also recorded.

Differences between the two groups were compared using Student's paired *t*-tests and chi-square tests, as appropriate. Probability values of less than 0.05 were considered statistically significant.

Results

Both groups were matched with respect to age, body weight, gender, and operation performed. All the patients were cannulated via the right internal jugular vein and correct catheter placement was uneventful. There were no obvious differences between the groups for proper catheter tip positioning time and measured optimal catheter length (Table 2). During manipulation, the incidence of cardiac dysrhythmia was higher in group G than in group T, but the difference was not significant ($p = 0.09$). Although these premature atrial or ventricular contractions occurred during the

Table 1. Quality of intravenous electrocardiographic signals

Scores	Baseline drift	P-wave pattern	QRS waveform
3	Smooth	Defined easily	Define easily
2	Sporadic shift	Sporadic artificial signal	Sporadic artificial signal
1	Shifts at times	Artificial signals at times	Artificial signals at times
0	No discernible signal	No discernible signal	No discernible signal

Total scores were calculated by summing the numbers for each item. The total scores were rated and categorized into excellent (8, 9), good (6, 7), fair (4, 5) and poor (< 3) for the four groups.

catheterization procedures, the dysrhythmia resolved after adjustment or withdrawal of the catheter to its proper length. Thus, no dysrhythmic episode required administration of medication to correct.

The quality of IVECG signals for group G patients was excellent in 14, good in 12, and fair in four patients. In group T patients, IVECG signal scores were excellent in 12, good in 15, and fair in three patients. Satisfactory IVECG signal quality was observed in 26 of the 30 patients in group G and 27 of the 30 group T patients. Although group T had a lower total signal score compared with group G, the difference between them was not statistically significant (Table 3).

Discussion

The non-coring transduction probe functionally conducted the intravenous signals from a right arm electrode lead. Using this technique saved time to position the catheter correctly. This caused fewer dysrhythmic episodes during catheterization; however, this is not statistically significant. The technique utilizing the transduction probe conducted IVECG signals effectively.

In this study, both techniques for catheter tip positioning resulted in satisfactory quality of IVECG signals, as nearly equal numbers of patients in groups G and T (26/30 vs 27/30) had satisfactory signal quality. While group T obtained a lower total signal score compared to group G, the difference was not statistically significant between them. Both groups obtained low baseline signal scores compared to other qualitative signal items. Some intrinsic and extrinsic factors affecting baseline scores include direct current stored potential in the electrode, body motion, poor application of the electrode, and poor electrode contact, which can distort the baseline and cause significant artifacts [11]. Though the exact factor causing distortion of the ECG signals requires further investigation, the time-varying filter technique, which uses a bank of linear low-pass filters, and the low-pass filtering method that splits the raw ECG signal into a muscle noise-free

Figure. *A and B. The transduction probe (TP) was introduced into the injection cap (IC) connected to the distal orifice of the indwelling catheter (Cath). A sterilized right arm electrode lead (EL) was attached directly to the non-coring transduction probe.*

Table 2. Demographic data and characteristics of patients undergoing central venous catheterization (mean ± standard deviation)

	Group G	Group T
No. of patients	30	30
Age	55.4 ± 14.1	55.0 ± 13.0
Gender (M/F)	16 / 14	14 / 16
Weight (kg)	57.5 ± 8.5	61.3 ± 10.3
Time to proper catheter tip position (sec)	109 ± 47.2	103.3 ± 55.5
Catheter length (cm)	16.9 ± 1.4	16.9 ± 2.0
Dysrhythmia during catheterization	5	1
Operation performed		
Upper abdominal surgery	17	22
Low abdominal surgery	13	8

Group G = intravenous ECG signals conducted from guide wire; Group T = intravenous ECG signals conducted from the transduction probe.

part and a muscle noise-overlapping part should be considered to improve the quality of ECG signals [12, 13].

Catheter migration after central venous catheterization is a common event during the perioperative period. Positioning a patient for a surgical procedure might cause the catheter tip to move from its measured location. It has been demonstrated that catheter migration occurs when patients are moved from the supine to upright position, and the occurrence of catheter migration to the peripheral site (> 90 %) is greater than that to the central site (< 5%) [14]. Catheters typically migrated from mid-right atrium initially to low superior vena cava, and catheter tip migration was greater for catheters in the subclavian veins, in females, and in obese patients [15]. In addition, changing the posture of the upper limb can also cause catheter tip movement. Kasten et al demonstrated that the catheter tip advanced if the arm is moved from 90° abduction to the position of the arm lying across the chest [16]. Those catheter tips located in the upper portion of superior vena cava or the mid-atrial cavity may increase the incidence of cardiac arrhythmias, cardiac perforation, and thrombosis [17, 18]. Therefore, catheter tip position should be re-evaluated after surgical positioning changes. To minimize the adverse effects from migration of the central venous catheter tip, the transduction probe has the advantage of repeatedly utilizing the IVECG signal to confirm final catheter tip placement as patients' positions change. This is very difficult to do using the wire-conducting technique for IVECG signals.

Cardiac dysrhythmia has been well documented during procedures of central venous catheterization, whether the catheter is inserted centrally or peripherally. Over-insertion of the guide wire or the central venous catheter, causing direct stimulation to the right side of the heart, has been postulated to be the

Table 3. Separate and total scores for quality of intravenous electrocardiographic signals

	Group G (n = 30)		Group T (n = 30)		*p* value*
	Mean	SD	Mean	SD	
Baseline drift	2.1	0.7	2.0	0.6	0.54
P-wave pattern	2.6	0.5	2.4	0.6	0.80
QRS wave pattern	2.6	0.5	2.5	0.5	0.45
Total	7.1	1.5	6.9	1.4	0.53

Group G = intravenous ECG signals conducted from guide wire; Group T = intravenous ECG signals conducted from the transduction probe.
*Paired Student's *t*-test (no statistical significance).

causative factor [19–21]. Stuart et al reported that, during guide wire insertion, 41% of procedures resulted in atrial arrhythmias and 25% produced some degree of ventricular ectopy, 30% of which were ventricular couplets or greater [19]. To avoid intracardiac chamber stimulation, prior measurement of the proper length of guide wire or catheter should decrease the incidence of arrhythmia. Lee et al reported that in internal jugular vein catheterizations performed with previous measurement of the inserted length of J-wire, there were significantly fewer cardiac dysrhythmias compared to the group where the guide wire was inserted at will (28.4% vs 3.9%; $p < 0.05$) [22]. Monitoring the proper catheter length during catheterization has the effect of decreasing the incidence of cardiac arrhythmia, as demonstrated in our study (group G: 16.7%, group T: 3.3%). Therefore, preparing the proper length of guide wire to prevent overinsertion and correct placement of the central venous catheter under IVECG monitoring is important to decrease the likelihood of arrhythmias.

In summary, connecting the non-coring transduction probe to the right arm electrode lead provides satisfactory IVECG signals and requires no specific equipment. The technique appears to be as safe, simple, quick, and effective as the guide wire technique, but has the advantage of quick re-evaluation of catheter tip placement after moving the patient in preparation for surgery. We recommend this technique to evaluate the accuracy of catheter tip placement during central venous catheterization and the perioperative period.

References

1. Kohler TR, Kirkman TR. Central venous catheter failure is induced by injury and can be prevented by stabilizing the catheter tip. *J Vasc Surg* 1998;28:59–65.
2. Mukau L, Talamini MA, Sitzmann JV. Risk factors for central venous catheter-related vascular erosions. *JPEN J Parenter Enteral Nutr* 1991;15:513–6.
3. Weber T, Huemer G, Tschernich H, et al. Catheter-induced thrombus in the superior vena cava diagnosed by transesophageal echocardiography. *Acta Anaesthesiol Scand* 1998;42:1227–30.
4. Fuchs S, Pollak A, Gilon D. Central venous catheter mechanical irritation of the right atrial free wall: a cause for thrombus formation. *Cardiology* 1999;91:169–72.
5. Petersen J, Delaney JH, Brakstad MT, et al. Silicone venous access devices positioned with their tips high in the superior vena cava are more likely to malfunction. *Am J Surg* 1999; 178:38–41.
6. Tierney SN, Katke J, Langer JC. Cost comparison of electrocardiography versus fluoroscopy for central venous line positioning in children. *J Am Coll Surg* 2000;191:209–11.
7. Francis KR, Picard DL, Fajardo MA, Pizzi WF. Avoiding complications and decreasing costs of central venous catheter placement utilizing electrocardiographic guidance. *Surg Gynecol Obstet* 1992;175:208–11.
8. Wilson RG, Gaer JAR. Right atrial electrocardiography in placement of central venous catheters. *Lancet* 1988;27:462–3.
9. Watters VA, Grant JP. Use of electrocardiogram to position right atrial catheters during surgery. *Ann Surg* 1997;225:65–71.
10. Corsten SA, van Dijk B, Bakker NC, et al. Central venous catheter placement using ECG-guided Cavafix-Certodyn SD catheter. *J Clin Anesth* 1994;6:469–72.
11. London MJ, Kaplan JA: advances in electrocardiographic monitoring. In: Kaplan JA, Reich DL, Konstadt SN, eds. *Cardiac Anesthesia*. Philadelphia: WB Saunders, 1999:359–400.
12. Sornmo L. Time-varying digital filtering of ECG baseline wander. *Med Biol Eng Comput* 1993;31:503–8.
13. Wei D, Harasawa E, Hosaka H. A low-distortion filter method to reject muscle noise in multi-lead electrocardiogram systems. *Front Med Biol Eng* 1999;9:315–30.
14. Kowalski CM, Kaufman JA, Rivitz SM, et al. Migration of central venous catheters: implications for initial catheter tip positioning. *J Vasc Interv Radiol* 1997;8:443–7.
15. Nazarian GK, Bjarnason H, Dietz CA Jr, et al. Changes in tunneled catheter tip position when a patient is upright. *J Vasc Interv Radiol* 1997;8:437–41.
16. Kasten GW, Owens E, Kennedy D. Ventricular tachycardia resulting from central venous catheter tip migration due to arm position changes: report of two cases. *Anesthesiology* 1985; 62:185–7.
17. Miller JA, Singireddy S, Maldjian P, Baker SR. A reevaluation of the radiographically detectable complications of percutaneous venous access lines inserted by four subcutaneous approaches. *Am Surg* 1999;65:125–30.
18. Yilmazlar A, Bilgin H, Korfali G, et al. Complications of 1,303 central venous cannulations. *J R Soc Med* 1997;90:319–21.
19. Stuart RK, Shikora SA, Akerman P, et al. Incidence of arrhythmia with central venous catheter insertion and exchange. *JPEN J Parenter Enteral Nutr* 1990;14:152–5.
20. Fiaccadori E, Gonzi G, Zambrelli P, Tortorella G. Cardiac arrhythmias during central venous catheter procedures in acute renal failure: a prospective study. *J Am Soc Nephrol* 1996; 7:1079–84.
21. Ray S, Stacey R, Imrie M, Filshie J. A review of 560 Hickman catheter insertions. *Anaesthesia* 1996;51:981–5.
22. Lee TY, Sung CS, Chu YC, et al. Incidence and risk factors of guidewire-induced arrhythmia during internal jugular venous catheterization: comparison of marked and plain J-wires. *J Clin Anesth* 1996;8:348–51.

另一種正確置放中央靜脈導管的選擇

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金屬管絲(Wire stylet)常被用為心電圖探針，並以靜脈心電圖技術來正確置放中央靜脈導管。我們提出另一種技術，以轉導探針(transduction probe)連接右臂心電圖導線，再和以金屬線傳導心電圖的技術方式，做功效及靜脈心電圖訊號品質的比較。依隨機將 60 位患者分為 G(n = 30)及 T(n = 30)兩組。在 G 組中，靜脈心電圖訊號由金屬導線傳導來確定正確的導管頂端位置。在 T 組中，靜脈心電圖訊號由轉導探針傳導確定正確導管頂端位置。以連續 10 秒心電圖基準線漂移程度，P 波圖形及 QRS 波圖形的清晰狀況作為靜脈心電圖訊號傳導品質的評估。結果發現，兩組在確定正確的導管頂端位置的置放時間及測量出的最理想導管長度，並無明顯差異。G 組在操作過程中心律不整的發生率較 T 組高，然而並不具統計意義(P = 0.09)。在得到令人滿意的靜脈心電圖訊號品質結果方面，G 組有 26 位，T 組有 27 位。因此，我們認為轉導探針亦能有效的傳遞靜脈心電圖訊號且不需特殊工具，它是種可供選擇的技術用來正確放置中央靜脈導管。

關鍵詞：心電圖訊號；金屬導線；轉導探針；中央靜脈導管

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