An In vitro Study of Guidewire-Related Color Doppler Twinkling Artifacts in Echocardiography

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Abstract

Purpose: This study sought to determine the association between twinkling artifacts on color Doppler ultrasound and different types of guidewires. Materials and Methods: Twenty-two commonly used guidewires were classified into three groups according to decreasing diameter (Group 1, 0.035”; Group 2, 0.018”; and Group 3, 0.014”) and tested in vitro. Severity of twinkling was visually graded into four categories (0–3, from weak to strong). Results: The percentages (tips/shafts) of twinkling artifacts were 100%/100% for Group 1; 0%/33.3% for Group 2; and 18.8%/31% for Group 3. The mean scores (tips/shafts) were 2.3/2.7 for Group 1; 0/0.3 for Group 2; and 0.3/0.4 for Group 3. Among them, both two guidewires with strong twinkling artifacts (score = 3) exhibited extensive rough surfaces on microscopic pictures. Conclusion: The twinkling artifacts were more likely to present in guidewires with larger diameters (from 0.014” to 0.035”) in our study settings. The surface roughness may be the contribution to the twinkling artifact. Internal heterogeneities, such as types of material, types of coating, tip loading, and spring coil length, do not show influence on the twinkling artifact.

Keywords: Doppler, guidewire, intervention, twinkling artifact

Introduction

First mentioned by Rahmouni et al., the twinkling artifact is a color Doppler phenomenon which appears as a rapid alternating mixture of red-and-blue color Doppler signals behind highly reflective objects. Although the underlying mechanism is not fully understood, previous studies have reported that twinkling artifacts are related to rough surfaces with multiple reflectors.[1] Others have suggested that twinkling artifacts could be caused by internal machine noise[2] or are associated with machine settings.[2-4] This artifact has also been described behind calcifications in various extracardiac tissues including prostate, testis, kidney, bladder, liver, gallbladder, breast,[11] ureter,[2] orbit,[6] and pancreas,[7] as well as calcified cardiac valves during echocardiography.[8]

Ultrasound-guided procedures are widely used currently in cardiac interventions and they can be applied via transthoracic or transesophageal echocardiography or intravascular ultrasound.[9] In a recent study, Bennett et al. reported intracardiac device-related twinkling artifacts when a patient received interatrial septal puncture for placement of a left atrial ablation catheter in transesophageal echocardiography. Twinkling artifacts were intermittently identified behind a superstiff 0.032” guidewire close to the interatrial septum and might be misinterpreted as a patent foramen ovale with a high-velocity, left-to-right shunt flow in transesophageal echocardiography.[10] The authors indicated that twinkling artifacts occurred in situations with well-demonstrated color figures; however, the association between the twinkling artifacts and the type of guidewire was not completely evaluated.[10]

The hypothesis underlying this study was that the various diameters and/or bondable coatings that make up the different

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types of guidewires might influence the presence or strength of the twinkling artifact. An in vitro study was conducted to systemically evaluate device-related twinkling artifacts using the various types of guidewires commonly used in cardiac intervention.

**Materials and Methods**

**Guidewires**

Twenty-two different types of guidewires, commonly used in cardiac intervention at our institution, were evaluated. Guidewire diameters included 0.035\" (Group 1, \(n = 3\)), 0.018\" (Group 2, \(n = 3\)), and 0.014\" (Group 3, \(n = 16\)). In cardiac intervention, 0.035\" guidewires are used for peripheral arteries, while both 0.014\" and 0.018\" guidewires are used for coronary arteries. Among them, 13 of 22 (59\%) guidewires used platinum and stainless steel coil as material, 2 (9\%) used superelastic nickel-titanium (Ni-Ti) coil, 2 (9\%) used Selenatun™ stainless steel coil, 2 (9\%) used platinum coil tip and Ni-Ti shaft, and the other 3 (14\%) were of unknown material. Regarding the coating, 9 (41\%) of the guidewires had hydrophilic (HY) coating; another 6 (27\%) were of polymer sleeve and HY coating and 4 (18\%) had silicon coating. There were two guidewires (9\%) with different coatings on the tip versus the shaft: one had HY coating on the tip and polytetrafluoroethylene (PTFE) on the shaft; another had silicon coating on the tip and PTFE on the shaft. The other guidewire (5\%) had an unknown coating.

Table 1 summarizes the characteristics of the guidewires including their diameters, materials, coatings, tip loadings, and spring coil lengths.

**Color Doppler ultrasound**

The color Doppler images of the twinkling artifacts produced by guidewires were acquired using an Acuson Sequoia 512 sonography machine (Siemens Medical Solutions, Mountain View, CA, USA) using an adult cardiac curved transducer (4V1c, 2–4 MHz; Siemens Medical Solutions). With a fixed probe in a water bath [Figure 1], all the images were obtained by a cardiologist (J. H. S) and a radiologist (T. F. T) with 14 and 12 years of experience, respectively, in ultrasonography. For prevention of air bubble contamination,[11,12] all guidewires were shaken manually in another water bath to release surface-trapped microbubbles.

Images were separately focused on the shafts and tips of each guidewire. The frequency and dynamic range of gray-scale images were 4.0 MHz and 72 dB, respectively. Native tissue equalization technology was used to automatically optimize gray-scale gain and depth gain compensation across the two-dimensional images. The distances between the probe and the guidewires were also fixed.

For color Doppler images, a red-and-blue color map was used. The color window size was set in a constant area which entirely covered the guidewires, as well as the twinkling artifacts behind the guidewires. The Doppler frequency and velocity were set at 4.0 MHz and 32 cm/s, respectively. The color gain was set at 11 to maximally enhance twinkling artifacts and eliminate background noise in the in vitro system. Other parameters for the images included depth of the field of view (image depth), 60 mm; number of transmit zones (number of focus points), 2; focal distance (length), 3.0 and 6.0 cm; distance between the transducer and the guidewire, 3.0 ± 1.0 cm; frame rate, 16 Hz; persistence number, 0; edge factor (sharper/smooth color distinction), −2; postprocessing map, 4; size factor of color gate, 1; and filter setting, 2.

**Analysis of twinkling artifacts**

To assess the strength of the twinkling artifacts, color Doppler images were organized in a randomized fashion and reviewed in consensus by two observers (Y. J. H and S. P. W) with experience in assessing the artifacts. Observers were aware that artifacts were associated with guidewires but unaware of the types of guidewires used in each study. For scaling twinkling artifact within the color window, images were assigned the following scores: 0, if there was no artifact; 1, if artifacts were present weakly behind or superimposed on only a small part of the guidewire; 2, if they were present immediately behind or superimposed on some part of the guidewire; and 3, if they were present strongly behind or superimposed on the entire guidewire. The score of the color Doppler twinkling artifact from each guidewire was recorded.

**Results**

The results are summarized in Table 2 and Figure 1. The percentages of tips/shafts with twinkling artifacts showed large variations between groups. In Group 1 (0.035\"), all the 3 (100\%) guidewires had twinkling artifacts at both tips and shafts. In Group 2 (0.018\"), none of the 3 (0\%) guidewires had the twinkling artifacts at its tip; one of the 3 (33.3\%) guidewires had the twinkling at its shaft. In Group 3 (0.014\"), three of the 16 (18.8\%) guidewires had twinkling artifacts at their tips; five of the 16 (31.3\%) guidewires had twinkling artifacts at their shafts.

Guidewires with larger diameters exhibited stronger twinkling artifacts than those with smaller diameters. Strong twinkling artifacts (score = 3) from two guidewires were exhibited by Group 1 only and both the two guidewires showed extensive rough surfaces on microscopic pictures. The average scores (tips/shafts) were 2.3/2.7 for Group 1; 0/0.3 for Group 2; and 0.3/0.4 for Group 3. Other parameters, such as type of material, type of coating, tip loading, and spring coil length, did not show any influence on the artifact.

**Discussion**

The twinkling artifact presents as a dynamic color mosaic on the surface of hard objects on a color Doppler ultrasound display. In addition to machine settings,[2-4] previous studies have reported that twinkling artifacts are related to rough surfaces with multiple reflectors that are usually associated with calcifications.[11]

Device-related twinkling artifacts have also been previously reported. Examples have included biopsy needle and drainage tips,[13,14] encrusted indwelling ureteral stents,[15] nephrostomy
Guidewire-related color Doppler twinkling artifact

Using the Doppler technique, echocardiography can provide flow information in real-time during the above-mentioned procedures in spite of the potential impact of the twinkling artifacts. In the present study, we proposed that twinkling artifact should not be mistaken for intracardiac flow but rather indicates the guidewire’s position.

According to the design of the manufacturer, the distal part of the guidewire is usually composed of spring coils on its surface for maintaining torqueability. We suppose that this spring coil, regardless of material (superelastic Ni-Ti, platinum and stainless coil, Scitanum™, and stainless coil), may offer some degree of surface roughness and induce the twinkling artifact. This hypothesis is thought to be supported with microscopic pictures. Guidewires with strong twinkling artifacts (score = 3) exhibit rough surfaces with scalloped contours whereas those with no or weak twinkling artifacts (score = 0 or 1) present smooth surfaces [Figure 2]. However, we do not quantitate the surface roughness based on microscopic pictures and this limit any more advanced explanation.

Based on our study, the diameter from 0.014” to 0.035” of a guidewire was also an important factor in generating twinkling artifacts, as well as the guidewire-related twinkling artifacts seen during interatrial septal puncture in a recent case-limited report by Bennett et al. In cardiology, echocardiography-assisted guidance during cardiac intervention has been used widely, such as in atrial septostomy, blade atrial septectomy, balloon dilation, atrial septal defect closure, ventricular septal defect closure, patent ductus arteriosus closure, and pericardiocentesis. Using the Doppler technique, echocardiography can provide flow information in real-time during the above-mentioned procedures in spite of the potential impact of the twinkling artifacts. In the present study, we proposed that twinkling artifact should not be mistaken for intracardiac flow but rather indicates the guidewire’s position.

| Group 1 (diameter: 0.035”) | Product name  | Material  | Coating       | Tip loading (g) | Spring coil length (cm) |
|---------------------------|---------------|-----------|---------------|-----------------|-------------------------|
| Angiography Guide Wire    | Superelastic Ni-Ti coil | Hydrophilic | 7/10          |
| Fixed-core-J-curve        | Platinum and stainless coil | Silicon |               |
| Amplatz Super             | Platinum and stainless coil |               |               |
| Stiff - Straight Tip      |               |           |               |
| Group 2 (diameter: 0.018”)| Angiography Guide Wire V-18 short taper | Superelastic Ni-Ti coil | Hydrophilic | 7.6 | 8 |
| V-18 short taper          | Platinum and stainless coil | Polymer sleeve and hydrophilic | 12/18/25/30 | 3 |
| Group 3 (diameter: 0.014”)| Victory-18    | Platinum and stainless coil | Polymer sleeve and hydrophilic | 0.8 | 11 |
| Fielder FC                | Platinum and stainless coil | Polymer sleeve and hydrophilic | 0.7 | 28 |
| Sion                      | Platinum and stainless coil | Hydrophilic | 1.7 | 15 |
| Gaia First                | Platinum and stainless coil | Hydrophilic | 3.5 | 15 |
| Gaia Second               | Platinum and stainless coil | Hydrophilic | 1 | 25 |
| Runthrough Floppy         | Platinum coil tip and Ni-Ti shaft | Tip HY coat shaft PTFE coat | 3.1 | 25 |
| Runthrough Intermediate   | Platinum coil tip and Ni-Ti shaft | Tip silicon coat shaft PTFE coat | 3 | 11 |
| ULTI MEBros3              | Platinum and stainless coil | Hydrophilic | 3 | 11 |
| Miracle 3                 | Platinum and stainless coil | Silicon | 3 | 11 |
| Miracle 6                 | Platinum and stainless coil | Silicon | 6 | 11 |
| Miracle 12                | Platinum and stainless coil | Silicon | 12 | 11 |
| Conquest Pro              | Platinum and stainless coil | Hydrophilic | 9 | 20 |
| Conquest Pro 12           | Platinum and stainless coil | Hydrophilic | 12 | 20 |
| PT2 LS                    | Platinum and stainless coil | Polymer sleeve and hydrophilic | 6 | 8 |
| PT2 MS                    | Platinum and stainless coil | Polymer sleeve and hydrophilic | 6 | 8 |
| Choice PT                 | Platinum and stainless coil | Hydrophilic | 6 | 8 |

HY: Hydrophilic, PTFE: Polytetrafluoroethylene

**Figure 1**: Photograph of the water bath used in our study. A 4V1c adult cardiac curved transducer (white arrow) is packaged by a latex examination glove and held by a clamp (black arrow). A blue 0.035” guidewire (arrowheads) under the water is visible.
artifacts, and we found that the larger the diameter, the stronger the twinkling artifact. On the other hand, other parameters, such as material, coating, tip loading, or spring coil length, did not show any association with the twinkling artifact. We believe that these internal heterogeneities do not affect the surface roughness and therefore, did not influence the twinkling artifact.

There were small differences between the twinkling artifacts observed at the tip versus those at the shaft of the guidewire in our study. The twinkling artifacts at the shafts were usually equal (and occasionally slightly stronger) than those at the tips. Since the tip of the guidewire was shaped in a curve, there was a larger angle deviation between the Doppler beam and the guidewire (the Doppler beam was not perpendicular to the object) in scans of the tip versus scans of the shaft. When the steeper angle occurred, the strength of the twinkling artifact behind the tip decreased. This phenomenon may explain the different results obtained between the tips and shafts in our study.

Our study had several limitations. Although we tested the most commonly used guidewires available at our institution, the sample size of the study was still small. In addition, different parameter settings were not tested in our study. This may have led to an underestimation (or overestimation) of the impact of the twinkling artifact on echocardiography. Finally, because our in vitro study was in a static environment, results may not be directly applicable to the clinical setting which involves cardiac motion during the scan.

Table 2: Color Doppler twinkling artifact scores with respect to tips versus shafts of guidewires

| Product name                  | Scores (mean)* | Group |
|------------------------------|----------------|-------|
| Angiography Guide Wire       | 1 2.3 2 2.7 1  | Tip   |
| Fixed-core-J-curve           | 3 3            | Shaft |
| Amplatz Super Stiff-Straight Tip | 3 3     |       |
| Angiography Guide Wire       | 0 0 0.3 2     |       |
| V-18 short taper             | 0 1 0         |       |
| Victory-18                   | 0 0           |       |
| Fielder FC                   | 0 0.3 0.4 3   |       |
| Sion                         | 2 2           |       |
| Gaia First                   | 1 1           |       |
| Gaia Second                  | 0 1           |       |
| Runthrough Floppy            | 0 0           |       |
| Runthrough Intermediate      | 0 0           |       |
| ULTIMATEebros3               | 0 0           |       |
| Miracle 3                    | 0 0           |       |
| Miracle 6                    | 0 0           |       |
| Miracle 12                   | 0 0           |       |
| Conquest Pro                 | 1 2           |       |
| Conquest Pro 12              | 0 1           |       |
| PT2 LS                       | 0 0           |       |
| PT2 MS                       | 0 0           |       |
| Choice PT                    | 0 0           |       |
| V-14 short taper             | 0 0           |       |

*0: Absence of twinkling, 1: Weak twinkling, 2: Intermediate twinkling, 3: Strong twinkling
**Conclusion**

We systemically evaluated guidewire-related twinkling artifacts in vitro. In our study settings, using the same scan parameters, twinkling artifacts were stronger and more likely present in guidewires with larger diameters. The surface roughness is considered the contribution to the twinkling artifact. Other parameters, such as material, coating, tip loading, and spring coil length, did not influence the phenomenon. The twinkling artifact, if occurs, should not be mistaken for intracardiac flow. On the contrary, it indicates the location of the guidewire during cardiac intervention.

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**Conflicts of interest**

There are no conflicts of interest.

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