INTRODUCTION

Progress in contrast ultrasonography has largely been a consequence of the development of contrast-specific imaging methods that have arisen from improvements in our understanding of the behavior of bubbles in an acoustic field. These exploit their nonlinear behavior, including the generation of higher and subharmonics and their disruption when exposed to high incident pressure sound waves.

Although recently introduced new sonographic technology including second harmonic imaging (HI) and pulse inversion harmonic imaging (PIHI) possess unique technical aspect, comparison of each imaging modalities according to technical aspect—particularly, the effects of transducer output power and scanning method on contrast enhancement, has not been performed systemically.

In this exhibit, we present comparison of these technical aspects of three contrast-enhanced ultrasonography — Fundamental imaging (FI), Second Harmonic Imaging (HI) and Pulse Inversion Harmonic Imaging (PIHI) using a flow-phantom.

MATERIAL AND METHODS

Flow Phantom

- A portable unit for live simulation of echo-enhanced examination (PULSE, Schering AG, Engineering Research) consisted of an electronic flow controller, a pump, a vessel, a reservoir of blood-mimicking fluid, and a distilled and degassed water tank
- Blood-mimicking fluid (distilled and degassed water with a small amount of a silicone oil emulsion additive)
- Thin-walled latex vessel (8-mm diameter)

US Scanning and Analysis

- ATL HDI 5000 equipment and a 2.5 MHz curved linear array transducer
- Fixing transducer with a clamp and placing the transducer at a 90° angle on the surface of the phantom under fixed slow non-pulsatile flow (10 mL/sec) and 2D gain

RESULTS

<p>| Table 1. Mean Value of FI, HI, PIHI During Intermittent Scanning |</p>
<table>
<thead>
<tr>
<th>US technique</th>
<th>0.2</th>
<th>0.3</th>
<th>0.5</th>
<th>0.9</th>
<th>1.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>FI</td>
<td>0.6</td>
<td>1.3</td>
<td>6.2</td>
<td>42.9</td>
<td>62.1</td>
</tr>
<tr>
<td>HI</td>
<td>4.3</td>
<td>10.0</td>
<td>55.0</td>
<td>118.6</td>
<td>169.3</td>
</tr>
<tr>
<td>PIHI</td>
<td>25.7</td>
<td>51.7</td>
<td>90.9</td>
<td>206.8</td>
<td>217.0</td>
</tr>
</tbody>
</table>

(p < 0.0001)

DISCUSSION

When properly insonated at increasingly higher mechanical indices (MI), microbubbles display non-linear scattering properties which lead to generation of harmonic components or bubble destruction. The maximum detectability is reached when MI of the US beam is high enough to destroy bubbles and produce a transient high-intensity wideband signal which can be detected using specifically designed US techniques.

In general, increases of MI in any contrast-enhanced sonographic techniques cause more stronger enhancement of flow signal intensity. However, there are significant differences in the intensity and duration of contrast enhancement among imaging modalities as well as scanning method. In our results, intermittent scan of PIHI showed best depiction of flow signal intensity. Although high MI group, intermittent scanning with PIHI revealed prolonged enhancement of flow signal. Therefore, PIHI can offer better delineation of vessels even at low MI because of its superior sensitivity to agent and better resolution of bubble disruption, especially in assessing slow flow.