



# **EFSUMB Course Book, 2nd Edition**

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## **Interventional Ultrasound**

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## Introduction

Ultrasound imaging has numerous outstanding advantages recognized by medical professionals throughout a wide range of specialties. However, one of its most versatile features continues to be the capability to visualize, in real time, a handheld needle passing through layers of muscles, fat and organs on its way to a target – decided by you - deep inside the body. Interventional ultrasound as a modality was introduced to clinical medicine in the late sixties and early seventies, and since then the number of applications has been constantly increasing [(1, 2, 3)]. No other imaging modality can compete with ultrasound when it comes to degree of freedom regarding the puncture route and thereby optimize the possibility of placing the needle correctly in the target and at the same time minimizing the risk of complications [(3-7)].

The applications of interventional ultrasound are countless but can be divided into two major groups: Diagnostic and therapeutic intervention. Diagnostic interventions include biopsy of solid tissue, aspiration of fluid and instillation of diagnostic material such as for instance contrast agents through a catheter. Therapeutic interventions comprise drainage of fluid collections like ascites, pleural and pericardial effusions, lymphoceles and abscesses, tubulation of hollow organs as in nephrostomy, gastrostomy and cholecystostomy and tissue ablation by means of heat, frost or radiation.

Regardless of the purpose of the intervention the principles of ultrasound guidance remain the same and can be described as either the “needle guide” or the “free hand” technique. This article describes the basic principles.

## Ultrasound guidance technique

For the inexperienced user it is advisable to practice the technique on a biopsy phantom before doing interventional procedures on patients, even if the first procedures are performed under supervision of an experienced colleague [(8)]. A biopsy phantom can be acquired from manufacturers of ultrasound equipment or it can simply be made of a suspension of gelatin in a small container filled with “biopsy targets” such as grapes or other small organic items [Figure 1].

**Figure 1** Biopsy phantom a) Box with gelatin and a grape. Two-dimensional scan-plane of US transducer indicated with grey. b) When transducer is moved to visualize grape, it becomes a perfect biopsy target.

a



b



For a good understanding of the fundamental principle it is furthermore recommended to start doing interventions utilizing a needle guide to familiarize oneself with working the needle with one hand while controlling the transducer - and thereby the scan plane - with the other hand [(9)]. The two hands are not supposed to work independently but on the contrary are to work in a synergy, as were they one piece of equipment. A needle guide is a dedicated device, purpose-made to fit a specific transducer or set of transducers in a way that makes an electronically displayed puncture line on the monitor correspond with the actual path a needle or catheter will take when introduced through the needle canal on the guide [Figure 2].

Needle guides are most often disposable utensils. Using a needle guide provides safer control of the needle during insertion, but it is on the cost of lesser flexibility of needle manipulation and limited degree of freedom regarding puncture direction. The transducer produces two-dimensional images of the scanned object. The need to consider the third dimension, i.e. the orthogonal plane, is eliminated, as the guide will keep the needle in the scan plane. The transducer is moved over the area of interest until the scan sector traverses the target, which is then visualized on the scan monitor [Figure 2].

Pressing the needle guide button on the scanner displays the puncture line, which appears on the monitor. The transducer is then moved until the puncture line goes through the target which implies that a needle inserted through the attached needle guide will eventually also be able to hit the target. The point where the needle will penetrate the skin is marked and local anesthesia is applied if needed. The needle guide is mounted on the transducer and depending on the size of the device to be inserted a small skin incision may be necessary. The planned intervention can now be performed and if necessary consecutive needle passes can be made through the same incision.

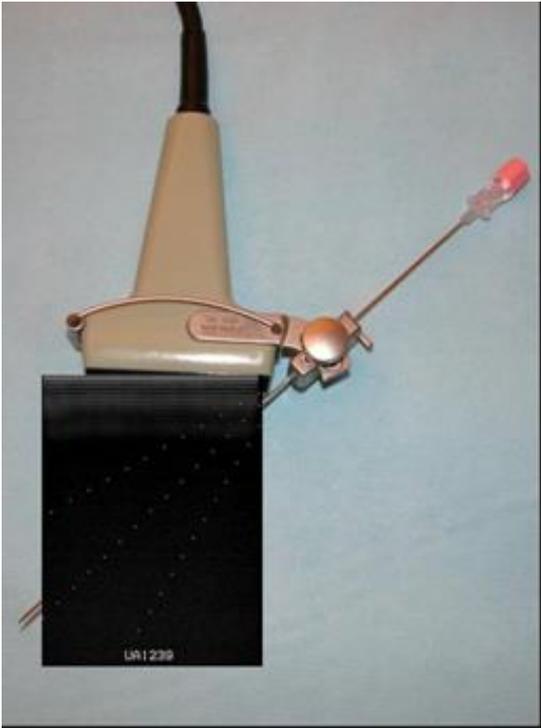
**Figure 2 Needle guide techniques. a) Needle guide attached to transducer and needle inserted. This particular guide has 3 different puncture angels: "horizontal", "vertical" and "in between". Image shows "horizontal" angel. b) Ultrasound image displaying all 3-puncture lines is superimposed on picture of transducer to show how the needle follows the predetermined angel. In this case the guide is set to the "in between" angel. c) Ultrasound image of biopsy phantom with grape. None of the 3 possible needle paths goes through the target. d)**

**Ultrasound image illustrating that transducer has been moved to allow a needle to be inserted through puncture line “vertical” to hit the target.**

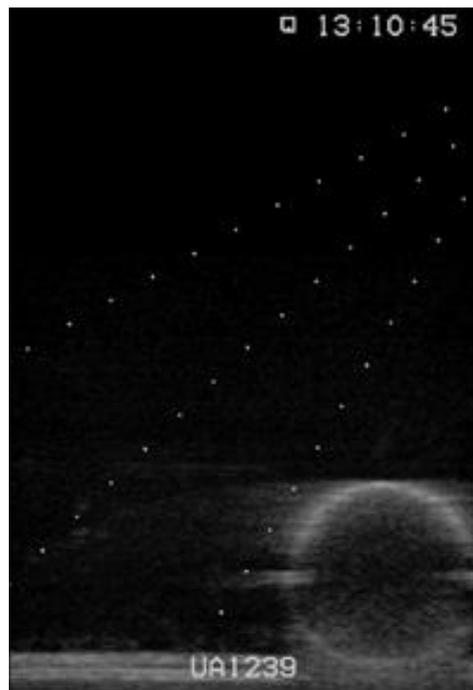
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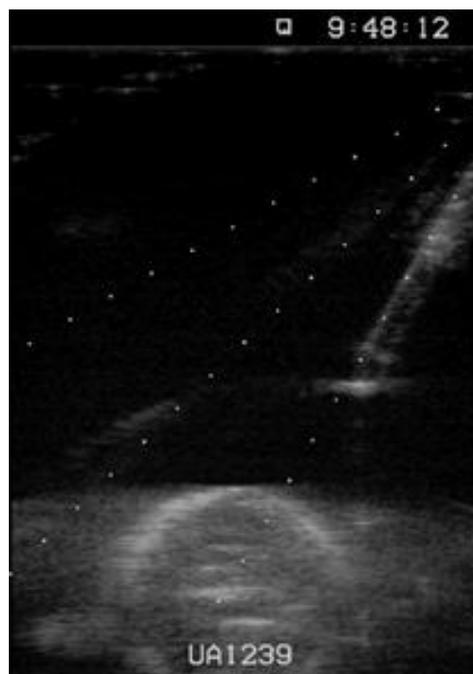
b



c



d



With the “free hand” technique there is no physical connection between needle and transducer and thus no limitations exist regarding point of needle insertion or angle of puncture. There is no puncture line on the monitor and the needle may be inserted from any direction parallel or perpendicular to the scanning plane, whichever solution is most suitable according to the situation at hand [Figure 3]. However, only that particular part of the needle,

which is in the scan plane, can be seen on the monitor. This implies that usually the entire needle shaft should be visualized on the ultrasound image if the needle is inserted from the end of the transducer parallel to the scan plane, whereas, with a needle insertion from the side of the transducer perpendicular to the scan plane the needle is only seen as a single or double dot at the point where it traverses the scan plane. This makes it technically more delicate - and sometimes difficult - to perform a perpendicular “free hand” procedure. If the full path of the needle is not visualized care should be taken that the needle does not traverse any structures that may cause complications.

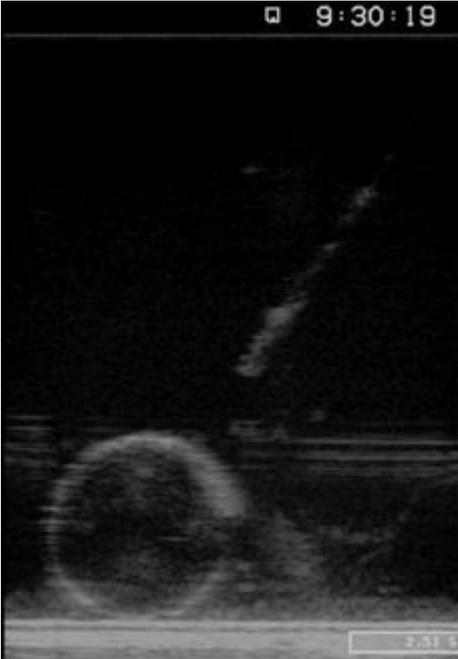
Some interventionists will speak strongly in favor of either the “free hand” or the “needle guide” technique and disregard the other. In our opinion this is a wrong attitude. Both the “needle guide” and the “free hand” techniques are excellent tools but like everything else in life also both have their advantages and drawbacks. When performing biopsy of a small lesion seated deep in the liver a needle guide is the obvious choice but if the target is a large superficial lesion the “free hand” technique may be just as safe and in addition quicker to use. If the lesion is not only superficial but also small and furthermore placed in a region difficult to access with full contact between transducer and skin – e.g., a lymph node in the supraclavicular region – the free hand technique may be the only option (physically there may not be room for the needle guide or it may be impossible to make the puncture line go through the lesion). Nephrostomy with Seldinger technique, on the other hand, is an example where the needle guide may be useful also for supporting the needle during guide wire insertion. Thus, generally speaking, the two techniques should not be looked on as conflicting with each other but rather as potential alternatives depending on the situation at hand.

**Figure 3 Free hand technique. a) Oblique needle insertion in the correct scanning plane. c) Ultrasound image of biopsy phantom with needle on its way towards grape. Entire needle shaft visualized. b) Oblique needle insertion perpendicular to scanning plane. d) Ultrasound image of grape in puncture phantom with needle tip inside grape. Notice that needle is only visualized as a white dot when it traverses the scanning plane, and one must be sure this dot does represent the needle tip before biopsy is taken.**

a



b



c



d



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