Radiology Techniques Department, College of Medical Technology, The Islamic University, Najaf, Iraq

Theoretical Radiation Physics

Third stage- Radiology Techniques Department

Lecture 8

By

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Radiation Physics precise specialization

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(Interaction of ultrasound with matter)

Acoustic impedance.

It is a measure of the resistance of the particles of the medium to mechanical disturbance, and It is denoted by (Z),

And where the acoustic impedance depends on the density of the medium and the speed of the sound waves in the medium, and where the acoustic impedance is expressed by the following equation

Acoustic impedance =density x velocity

$$Z=\rho x v$$

Acoustic boundaries.

Acoustic boundary is the surface between two materials of different acoustic impedance, Such as the boundary between the wall of the bladder and urine, where the acoustic impedance of urine different from the acoustic impedance of the bladder wall.

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The reflection of ultrasound waves

There are two types of reflection of ultrasound waves, they are specular reflection and non-specular reflection (scattering), and this can be explained as follows

specular reflection .

This type of reflection occurs when the dimensions of the acoustic boundary are greater than one wavelength In this type of reflection, the first and second laws of reflection are achieving, and they are as follows

angle of incidence = angle of reflection

The incident ray, the normal to the surface at the point of incidence, and the reflected ray, all lie in the Sam plane.

The intensity of the reflected waves depends on the angle of incidence and the acoustic impedance of the two mediums separated by the acoustic boundary.

To increase the probability of the reflected beam to go back to the transducer, the angle of incidence and the angle of reflection must be smaller or equal (3^o), and the **best**

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reflection occurs when the ultrasound waves incident perpendicular to the reflecting surface (acoustic boundary), and this case is called **normal incidence**, that is

$i=r=0$

In this case, the probability of picked up the reflected waves by the transducer is high, In this special case, the relationship between the intensity of the incident waves and the intensity of the reflected waves is expressed by the following equation

$$\mathbf{(I_r/I_i) = (Z_1 - Z_2)^2/(Z_1 + Z_2)^2}$$

Where

I_r: represent the intensity of reflected waves

I_i :represent the intensity of incident waves.

Z_1: represent acoustic impedance of first medium.

Z_2: represent acoustic impedance of second medium.

Where the ratio **(I_r/I_i)** is called the **acoustic reflection coefficient.**
Then
Acous.refl.coef= I_r/I_i
Also
Acous.refl.coef= $(Z_1-Z_2)^2/(Z_1+Z_2)^2$

When the difference (**Z_1-Z_2**) is **large**, this means that the intensity of the reflected wave (**I_r**) is **large**, and therefore the **acoustic reflection coefficient** is **large.**
When the difference (**Z_1-Z_2**) is **small**, this means that the intensity of the reflected wave (**I_r**) is **small**, and therefore the **acoustic reflection coefficient** is **small.**
The difference in the acoustic impedance as well as the difference in the percentage of the acoustic reflection coefficient can be seen through the following two tables.

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material	Acoustic impedance(rayl)
muscle	1.70
fat	1.38
brain	1.58
kidney	1.62
liver	1.65
blood	1.61
Soft tissue(average)	1.63
bone	7.8
air	0.0004

Acoustic boundary	% acoustic reflection coefficient
Muscle/fat	1
Kidney/fat	0.6
Bone/muscle	41
Bone/fat	49
Soft tissue/air	99.9
Soft tissue/water	0.2

If the acoustic impedance of muscle is (1.7rayl), and the acoustic impedance of fat is(1.38rayl), calculate the acoustic reflection coefficient for the acoustic boundary between muscle and fat(muscle/fat), then calculate the percentage of the acoustic reflection coefficient for that boundary.

Acous.refl.coef= $(Z_1-Z_2)^2/(Z_1+Z_2)^2$

$Z_1=Z_{muscle}$=1.70 rayl

$Z_2=Z_{fat}$=1.38 rayl

Aco.refl.coef=$(1.70-1.38)^2/(1.70+1.3)^2$

=0.01

Percent.aco.refl.coef=0.01x(100/100)

=1x(1/100)

=1%

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Acoustic impedance unit.

$Z=\rho x v$

$=(kg/m^3)x(m/sec)$

$= (kg/m^2.sec)$……………..(1)

We multiply equation (1) by (sec) and divided by (sec)

$Z=(kg.sec/m^2.sec^2)$

We multiply equation above by (m) and divided by (m)

$Z=(kg.m.sec/m^2.sec^2.m)$

Where

$N=kg.m/sec^2$

Then

$Z=(N.sec/m^2.m)$

Where

$Pa=N/m^2$

Hence

Z=Pa.sec/m………….(2)

Where

(Pa.sec/m)=rayl

Hence

Z=rayl……………….(3)