

IN-SERVICE REVIEWS IN DIAGNOSTIC MEDICAL SONOGRAPHY

INSTRUCTOR'S GUIDE

Volume 7 Number 9

CONTENT OUTLINE

Coordinated by Irwin Kuperberg, BS, RDMS

- I. An Explanation of Bioeffect Mechanisms
William D. O'Brien, PhD
Associate Professor, Department of Electrical and Computer
Engineering and Department of Bioengineering
University of Illinois
Urbana, Illinois
 - A. Background of bioeffect research
 - B. The thermal mechanism
 - C. Nonthermal mechanisms
 - 1. cavitation
 - 2. other
 - D. Implications
- II. What Is Cavitation?
Irwin Kuperberg, BS, RDMS
- III. Understanding Bioeffects Research
Andrea C. Skelly, BS, RDMS
Assistant Professor and Director
Diagnostic Ultrasound Program
Seattle University
Seattle, Washington
 - A. Perspective
 - B. Importance of intensity data
 - C. Research into biological effects
 - D. Factors to consider in reviewing the literature
 - E. The sonographer's responsibilities



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DISCUSSION GUIDE

PROGRAM: In-Service Reviews in Diagnostic Medical Sonography, Volume 7 Number 9

SUGGESTED USE (GENERAL):

1. Group study—Participants listen to the tape as a group. Time is allotted for working through the study guide with group discussion and quiz. Program is probably best completed in two 45-minute sessions.
2. Individual study—Participants listen to the tape and work through study guide individually on their own time. Quiz may be completed with or without supervision.
3. Combination individual and group—
 - a. Participants listen and work through the study guide individually, followed by group discussion and quiz.
 - b. Participants listen individually but work through guide in a group with group discussion and quiz.
 - c. Participants listen and study as individuals and are given specific topics to develop for group discussion.
 - d. Participants listen individually, then work through study guide and discuss as a group. The quiz may be completed individually.

SUGGESTED FORMAT (GROUP STUDY):

1. The discussion leader should make certain that all participants have a copy of the behavioral objectives for the tape.
2. The discussion leader should review each objective with the participants prior to playing the tape so that each objective is understood.
3. The cassette tape should be played while the participants listen and make notes. After each category, there should be a short discussion period to provide verbal interaction between the group leader and the participants.
4. Group leader should ask for any further questions concerning the entire tape and then distribute the quiz to each participant for completion at that time.
5. Emphasize the need for "feedback" from the participants concerning the tape. Ask that they add suggestions for material to be covered in future tapes (space supplied at the bottom of the quiz sheet).
6. Collect the quizzes and then review the answers provided in the instructor's material and answer any questions concerning the quiz.
7. For further emphasis, assign accompanying activities to individual participants and have them document their results. These results should be prepared for the next time the group gathers for in-service education. The participants should present their findings for discussion at the beginning of that session.
8. Complete documentation sheet (print or type) and keep for permanent departmental record.
9. Send comments to **Irwin Kuperberg, BS, RDMS**, State University of New York (SUNY), Health Science Center at Brooklyn, Box 1192, 450 Clarkson Ave, Brooklyn, NY 11203.

ABSTRACT

This issue takes a temporary departure from clinical matters to the important topic of bioeffects. Dr William O'Brien, author of dozens of articles on bioeffects, explains the mechanisms for bioeffect production in living tissue, concentrating on thermal effects and cavitation. Irwin Kuperberg then takes a further look at cavitation for those who have never been able to understand this confusing phenomenon. The program ends with a presentation by Andrea Skelly, Director of the Diagnostic Ultrasound Program at Seattle University and Chairman of the SDMS Bioeffects Committee. She explores the major issues related to the biological effects of ultrasound.

BEHAVIORAL OBJECTIVES

After listening to this tape, the participant will be able to

1. List and briefly describe the major mechanisms of bioeffect production.
2. Explain the difference between stable and transient cavitation.
3. List the major considerations in evaluating bioeffects research.
4. Adopt safety considerations in the ultrasound lab.

Table 1.—Table of Expressions	
$Q = 2\alpha I_{ta}$	(1)
$\Delta Temp_{max} = Q \Delta time / C_h$	(2)
Ballpark estimate:	
$I_{ta} = 100 \text{ mW/cm}^2$	
$\alpha = 0.15 \text{ cm}^{-1} \text{ at } 5 \text{ MHz}$	
$Q = 0.03 \text{ J/cm}^3 \text{-s}$	
$\Delta Temp_{max} / \Delta time = 0.007 \text{ }^\circ\text{C/s}$	(3)
$\Delta Temp_{max} / \Delta time = 35 \text{ }^\circ\text{C/s}$	(4)

WHAT IS CAVITATION?

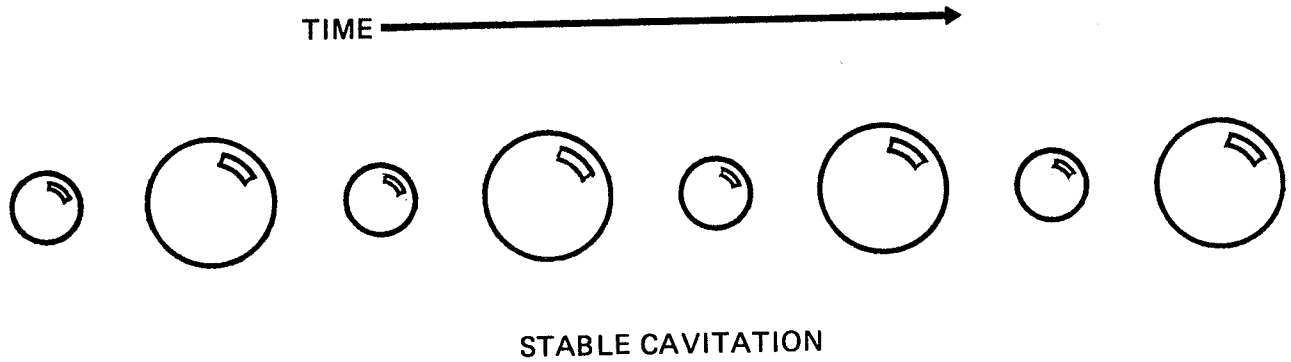


Fig 1.—In stable cavitation, bubble nuclei expand and contract under the influence of the acoustic cycle. During this process, bubble radius oscillates about a fixed value during numerous compressions and rarefactions.

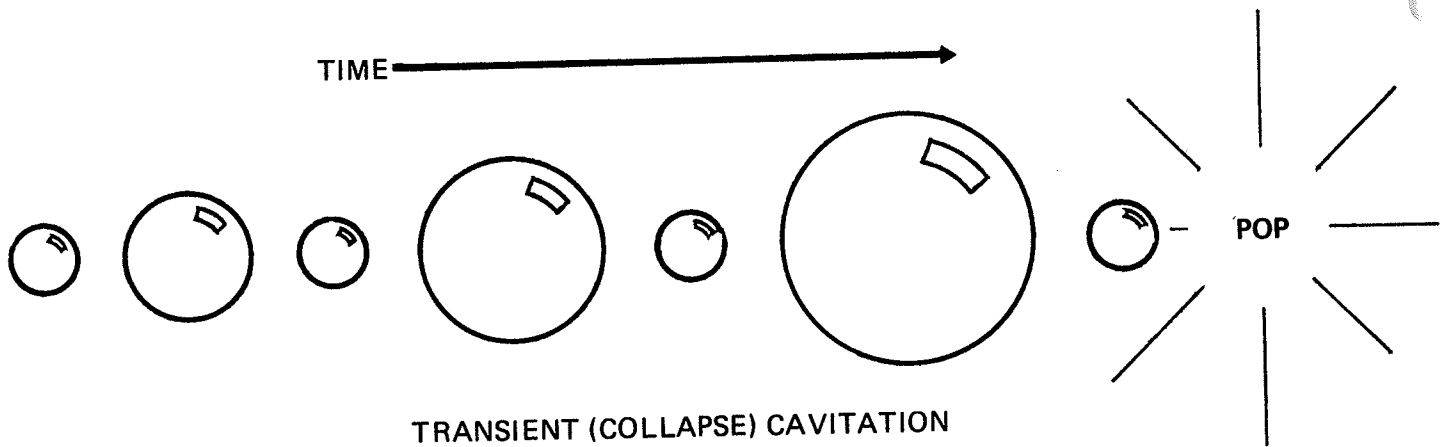


Fig 2.—Bubble radius in transient cavitation gets progressively larger with each succeeding cycle. In addition, the bubble persists for only a few cycles, then explodes.

Table 2.—Summary of Values of Various Acoustic Parameters by Class of Equipment*

Class of Equipment	Acoustic Power (mW)	I _{SPTA} (mW/cm ²)	I _{SPPA} (W/cm ²)
Manual compound scanners	0.5 - 20	10 - 170	0.5 - 280
Single crystal M-mode	0.5 - 20	10 - 100	0.5 - 110
Auto sector scanners			
(1) array and mechanical	9 - 20	6 - 30	25 - 100
(2) M-mode	3.5 - 20	45 - 160	25 - 100
Sequential linear arrays	0.1 - 33	0.01 - 12	0.2 - 70
Ophthalmic R-T	0.02 - 0.06	0.2 - 0.6	No data
Ophthalmic A/B mode	0.6 - 1	20 - 34	No data
Pulsed Doppler—cardiac	8 - 24	50 - 290	3 - 14
CW Doppler—OB compact/portable	1 - 18	0.6 - 20	Not applicable
CW Doppler fetal monitoring	5 - 32	9 - 80	Not applicable
CW Doppler (PV primarily)	6 - 105	110 - 2500	Not applicable
Pulsed Doppler—PV	6 - 10	350 - 700	1.6 - 12

Acoustic outputs and intensities of various classes of equipment and modes of operation are different. The magnitude of I_{SPTA} and I_{SPPA} for any given instrument is also quite different. Note that I_{SPTA} is given in mW/cm² while I_{SPPA} is in W/cm². Data for the array and mechanical autosectors are given for the scanning mode. (Adapted from NCRP Report No. 74.⁷)

* Reproduced from Skelly⁶ with permission.

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