Bone Densitometry

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Reasons to Measure Bone Density

- Osteoporosis is common - 44 million Americans have osteoporosis or low bone mineral density (BMD)
- Osteoporosis is serious - Osteoporotic fractures cause increased morbidity and mortality
- Osteoporosis is easy to diagnose - Bone density testing can detect osteoporosis before the first fracture occurs
- Good treatments are available- Fracture risk can be reduced by about 50%

Osteoporosis

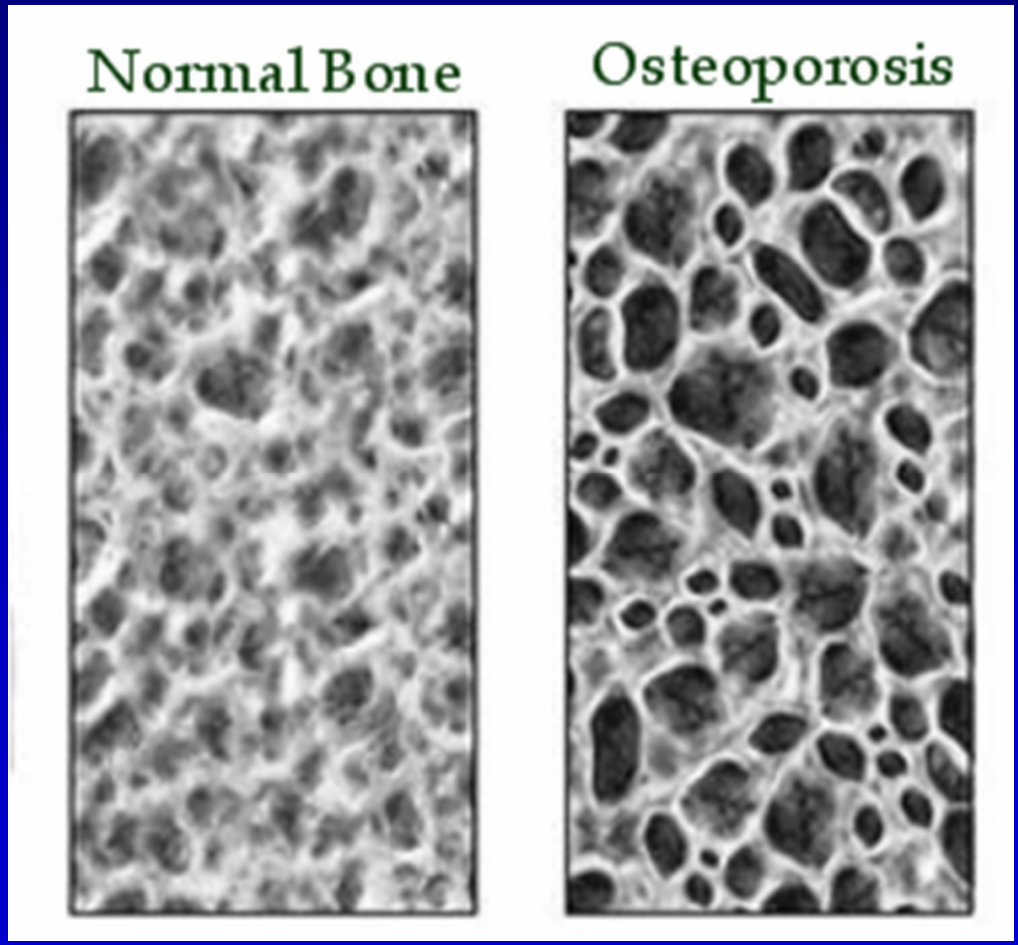
Osteoporosis is defined as "…is a systemic skeletal disease characterized by low bone mass and microarchitectural deterioration of bone tissue, with a consequent increase in bone fragility and susceptibility to fracture."

Osteoporosis is a silent condition (no signs or symptoms unless or until there are fractures)

There are no clinical tool to assess bone quality

Measurement of bone mineral density (BMD): to diagnose osteoporosis, to predict fracture risk, to monitor therapy

Osteoporosis



Risk factors for Osteoporosis

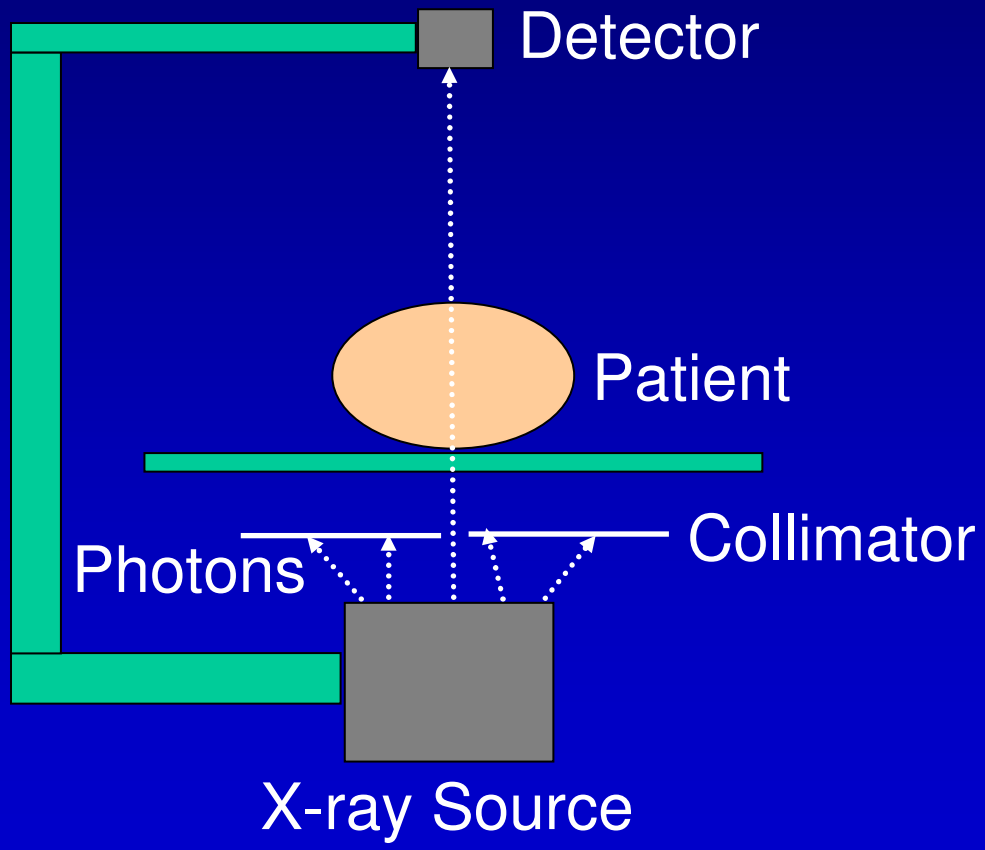
Women who have gone through menopause are most at risk. Menopause usually begins when a woman is about 50, although it can occur earlier if a woman has had surgery to remove her ovaries.

Other contributing risk factors include: Family history of osteoporosis, Caucasian or Asian descent, Thin or small build, Smoking, Excessive alcohol, Too little exercise, Too little calcium (now or as a child), A previous broken bone that resulted from a minor injury, certain medications, such as steroids (commonly used to treat asthma and arthritis) and thyroid hormone (if the doses are high), Early menopause

Dual Energy X-ray Absorptiometry

- DXA is the accepted acronym, current gold standard for diagnosing osteoporosis and monitoring patients.
- Safe, non invasive, high precision and accuracy, short investigation time, ease of use, minimal radiation exposure, multiple skeletal sites, widely available.
- Successor to dual-photon absorptiometry (DPA): Gadolinium -153 source: increased photon flux
- DXA is not a component of residency training and board certification in the US
- Other tests: Quantitative Ultrasound (QUS), Quantitative Computerized Tomography (QCT)

DXA Technology



(produces 2 photon energies with different attenuation profiles)

DXA Measurements

- Bone Mineral Density (BMD) is calculated in g/cm^2
- "T-score" compares the patient's BMD with the young-normal mean BMD and expresses the difference as a standard deviation (SD) score
- $\frac{\text{Patient's BMD} - \text{Young-Adult Mean BMD}}{\text{1 SD of Young-Adult Mean BMD}}$
- Z-score : $\frac{\text{Patient's BMD} - \text{Age-Matched Mean BMD}}{\text{1 SD of Age-Matched Mean BMD in } g/cm^2}$

WHO Diagnostic Criteria

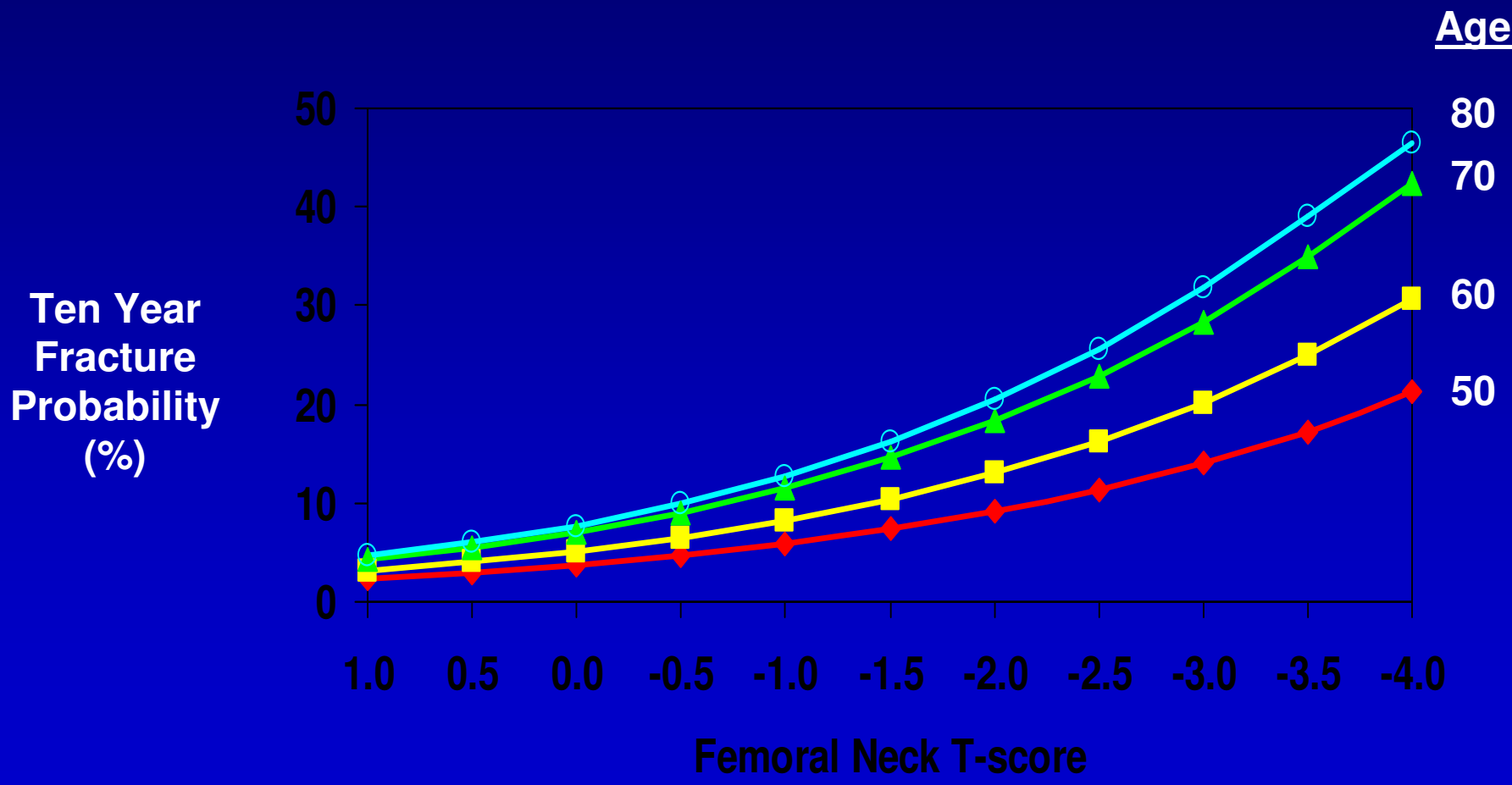
Classification	T-score
Normal	-1 or greater
Osteopenia	between -1 and -2.5
Osteoporosis	-2.5 or less
Severe Osteoporosis	-2.5 or less and fragility fracture

These cannot be applied to the techniques other than DXA of the spine and hip or in men or children or patients from other ethnic groups. For males <50 years, females prior to menopause or children, Z-score is used with –2.0 or lower as the criteria for calling "below the expected range for age"

T-Score

- T-score of 0 is equal to the young normal mean value.
- T-score is related to bone strength & fracture risk.
- Clinical diagnosis of osteoporosis may be made with T-score greater than -2.5
- T-score -2.5 or less does not always mean osteoporosis, e.g: osteomalacia, Low T-score does not identify the cause
- Discordant T scores: Different sites have different peak bone mass at different times and lose bone at different rates, different technologies, different ROIs, different reference databases have different means and SD
- Always Compare BMD, Never Compare T-scores

Bone Density (T-score) & Age vs. Fracture Risk



www.nuclearmd.com

Indications For Bone Density Testing

- All women age 65 and older
- All men age 70 and older
- Adults with a fragility fracture
- Adults with a disease associated with low bone density
- Adults taking medication associated with low bone density
- Anyone being treated for low bone density : monitor treatment
- Anyone not receiving therapy, in whom evidence of bone loss would lead to treatment

Skeletal Sites Measured/ Scanned

Every Patient

- Spine
  - L1-L4
- Hip
  - Total Proximal Femur
  - Femoral Neck
  - Trochanter

Some Patients

- Forearm (33% Radius)
  - If hip or spine cannot be measured
  - Hyperparathyroidism
  - Very obese

Use lowest T-score of these sites

Scanning Procedure

A bone densitometry study measures the calcium content (density) of your bones. A scanner that emits tiny amounts of radiation is used for this exam. Scans of your lower back, hip, or forearm are most often taken. You are having this exam because it has been determined that you are, or may be, at risk for *osteoporosis* (loss of bone mass). This exam can also show whether your medications are slowing down bone loss. No prior preparation is required.

Let the Technologist Know if You: are, or think you might be, pregnant, have any metal in the part of your body being imaged, such as spinal fusion rods or a hip replacement, have had a recent nuclear medicine scan or a barium enema, have a severely curved spine; have had spinal surgery, or cannot lie on your back for any reason.

Scanning Procedure

Patient Instructions: Wear clothing with no metal closures, such as zippers. You may have to remove your watch or other metal items that can affect exam results. You may also be asked to wear a patient gown. This test takes between 20 and 30 minutes. After Your Bone Density Test: You may return to your normal routine when your exam is over. Your doctor will let you know when your results are ready.

During Your Bone Density Test: You will be asked to lie down on a specialized table. For part of the test, your lower legs may be raised on a platform. This will help ensure the images taken will be clear. A scanner arm will be above you. This arm will move back and forth over the part of your body being scanned. During the exam, the technologist will stand or sit nearby. You will need to remain very still.

Imaging the Spine

Posteroanterior scans, patient lying supine on the imaging table, aligned in the middle of the table, spine straight and parallel to the longitudinal table axis, legs are elevated with the use of a foam wedge to minimize spinal lordosis and increase intravertebral spacing.

Scan starts from a point 2.5-5 cm below the anterior margin of the iliac crests (both the iliac crests should be visualized), and finishes just above the tip of the xiphoid (middle of T12 vertebra), includes part of the sacrum and pelvis, and part of a vertebra with ribs (that is usually T12). The L4–L5 interspace is correctly identified and intervertebral spaces are properly marked. There is adequate soft tissue on both sides.

Imaging the Hip

Ideally, the non-dominant side (usually the left hip) is scanned. Scan starts distal to the ischium and ends proximal to the greater trochanter. It includes the entire femoral head, the greater trochanter, and the proximal end of the femoral shaft at least 2.5 cm below the lesser trochanter. The shafts are straight, and there is optimal internal rotation (little or none of the lesser trochanters are showing).

Amount of internal rotation presents the long axis of the femoral neck perpendicular to the X-ray beam, providing the greatest area and the lowest bone mineral content (and the lowest BMD), and is confirmed on the scan by seeing little or none of the lesser trochanter

Reading the DXA Scans

On a printout from the DXA scanner, for each region of interest the area analyzed (expressed in cm^2), bone mineral density (BMD) (expressed in g/ cm^2) are reported.

Bone mineral density measurement are also expressed as a percentage of young-adult reference population (T-score) and as a percentage of age-matched reference population (Z-score).

The image should be evaluated for posotioning, artifacts (e.g. surgical clips, navel rings, radio-opaque tablets) or local structural change (e.g. osteophytes, compression fractures, aortic calcification).

Reading the DXA Scans

Going down the spine, the vertebrae are larger and have greater mineral content and density. BMD is usually measured for L2 to L4 levels of the lumbar spine

Spinal degenerative change (spondylosis), can elevate spine BMD. Absent bone (surgery or spina bifida) will spuriously lower BMD. Lateral DXA scanning of the lumbar spine may allow elimination of degenerative changes from the ROI.

The Ward's triangle is a region of approximately 3 cm^2, the area of lowest density in the center of the femoral neck. Use of the Ward's triangle is limited by the poor precision of measurements at this site and overestimation of disease.

Reading the DXA Scans

Peripheral densiometry : an alternative when patients have confounding disease or where axial measurements cannot be obtained owing to patient's weight, poor mobility, or difficulty in lying flat.

Serial measurements should be performed using the same DXA scanner. If an earlier DXA can is available for comparison, it is important to ensure that identical ROIs are used for BMD measurement. Spine is the best site for followup measurement.

Reading the DXA Scans

Correct performance of DXA measurements requires attention to detail in positioning and analysis.

Least Significant Change: A change in bone mineral density of less than 3% in the spine and 6% in the hip may not be significant.

It has been estimated that the radiation dose received during DXA scanning of the lumbar spine is equivalent to the exposure during a transcontinental airplane flight or spending a week in Denver, CO.

Bone Densitometry

- BMD Values From Different Manufacturers Are Not Comparable: Different dual energy methods, Different calibration, Different detectors, Different edge detection software, Different regions of interest
- Advanced DXA Features: Spine imaging (Vertebral Fracture Assessment - VFA), Absolute fracture risk reporting
- Peripheral BMD Testing:What it can do- Predict fracture risk, Tool for osteoporosis education, What it cannot do-Diagnose osteoporosis, Monitor therapy, A “normal” peripheral test does not necessarily mean that the patient does not have osteoporosis, WHO criteria do not apply

International Society for Clinical Densitometry (www.iscd.org)

- ISCD Certification: Personal recognition of bone densitometry skills, Demonstration of proficiency in bone densitometry for colleagues and managed care organizations, Marketing advantage for centers with certified staff, Required for reimbursement by some managed care organizations
- Bone Densitometry Course: Comprehensive 1½ day CME/CE course with separate tracks for clinicians and technologists, Essential education for bone densitometry center staff, Preparation for ISCD Certification Exam

Lympho-Scintigraphy

A Guide to Sentinel Lymph Node Biopsy

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Concept of Sentinel Lymph Node

Assumption that the tumor drains in a logical way through the lymphatic system, from the first to subsequent lymph node levels. The first lymph node encountered (the sentinel node) (SN) will most likely be the first affected by metastasis; therefore, a negative sentinel node makes it highly unlikely that other nodes in the same lymphatic basin are affected.

The sentinel node status distinguishes patients without nodal metastases, who can avoid nodal basin dissection with its associated risk of lymphedema, from those with metastatic involvement, who may benefit from additional therapy.

SN biopsy has been validated for *melanoma* and *breast cancer*.

Lympho-Scintigraphy

Lymphoscintigraphy is an essential part of radioguided sentinel lymph node biopsy. The initial injection of radiocolloid around the primary lesion, its progression along the lymphatic channels, and phagocytosis by macrophages in the SNs is the basis of imaging with the planar gamma camera.

The goals are to delineate the true SN, maximize activity in the node for facilitated removal (even at next-day surgery), and deliver the information to the surgeon without delaying the surgical schedule.

Lympho-Scintigraphy - Technique

Radiopharmaceutical: Technetium-99m sulfur colloid (most commonly used). Filtered (100 or 200 nm) or Unfiltered (100–1,000 nm diameter)
Tc-99m nanocolloid (Europe): almost all particles < 100 nm in diameter, instant labeling at room temperature and stability both in vitro and in vivo.

Activity and Volume: typically 200 µCi (7.4 MBq) to 2–3 mCi (74–111 MBq), in small volumes (0.05–0.2 mL), high specific activity preparations.

Injection Technique: local anesthetic skin cream, preventing skin contamination, applying negative pressure to the syringe during withdrawal and immediately dabbing the injection site with a gauze pad, bandaging the site after all injections are completed and keeping the patient's hands away from the sites, massaging the injection site after injecting the radiotracer, avoid injection into the pectoral muscle or a breast prosthesis for obvious reasons, avoid indurated or inflamed skin.

Lympho-Scintigraphy - Technique

Melanoma: Intradermal / subdermal injection using 25- or 27-gauge needles, just enough to produce a visible wheal in the skin, 0.5–1 cm away from the scar or the tumor margin. At least 4 separate tracer injections should be performed, roughly equatorially around the lesion or surgical scar.

Breast Cancer: Perilesional (also called *intraparenchymal* or *peritumoral*), Areolar, Intralesional, Cutaneous - into the skin above the lesion

Cutaneous injections: internal mammary nodes are not delineated, faster and brighter visualization of SNs, imaging can be performed after 30–45 minutes, radiotracer reaches SNs much faster due to the rich lymphatic drainage of the skin, much less volume of injection.

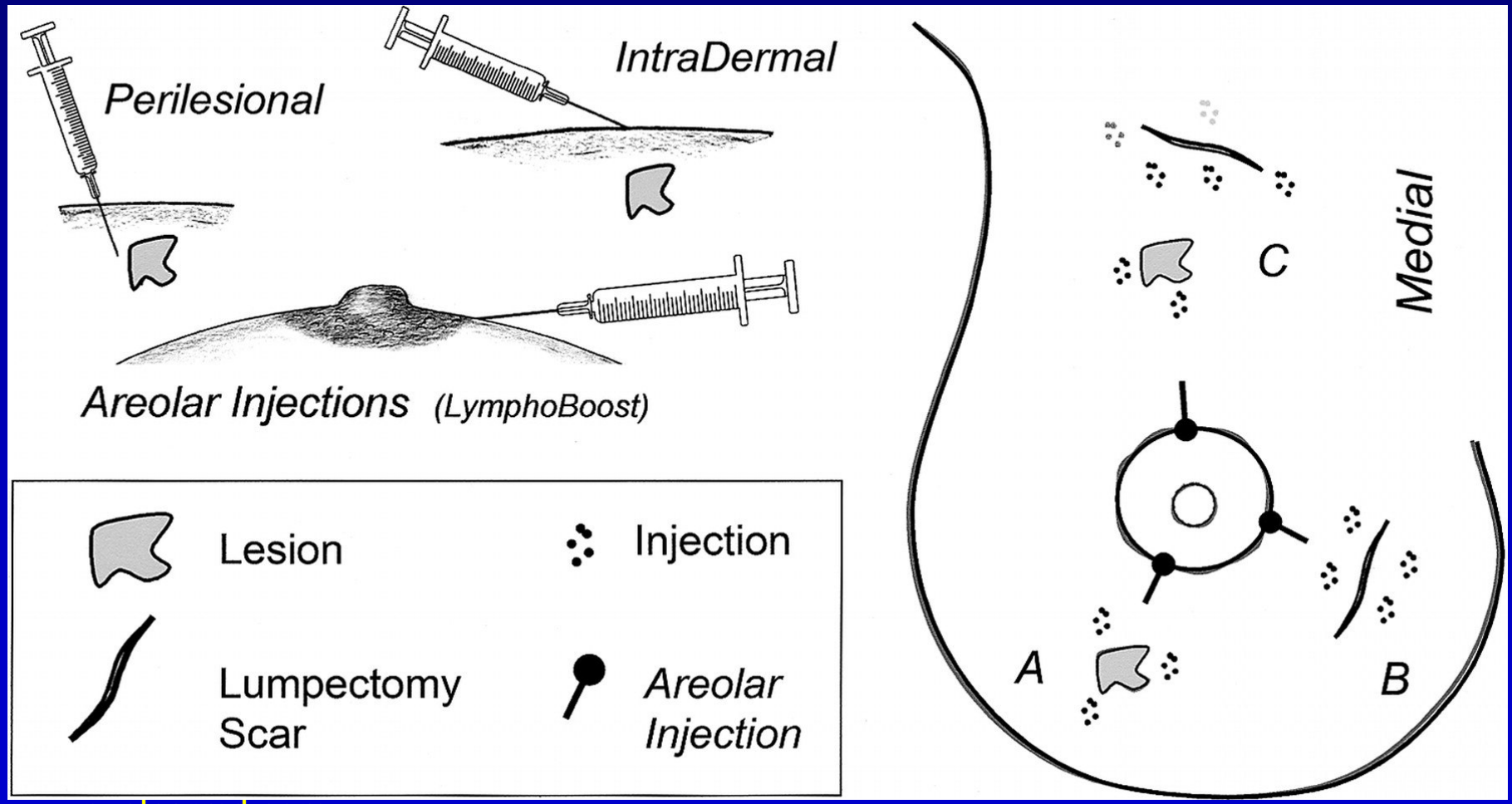
Lympho-Scintigraphy - Technique

Areolar Region Injections: low internal mammary node detection, low volumes of injection, fast SN visualization, more of the total dose reaches the SN compared with skin injections above the tumor.

Intralesional Injections: rarely, poor lymphatic drainage from the lesion, spread of disease-dislodging tumor cells, difficulty of finding the center of the lesion, less painful than intradermal more internal mammary nodes

Internal mammary node detection: enhanced by deeper perilesional injections, in younger patients, those with small breasts, primary lesion located medially and inferiorly in the breast

Lympho-Scintigraphy - Technique



Lympho-Scintigraphy - Imaging

Both dynamic and static scintigraphic acquisitions are essential to indicate the drainage basin, determine the number of SNs, locate SNs outside the usual nodal basins, and differentiate SN (first-echelon nodes) from nonsentinel nodes (second-echelon nodes).starting immediately after radiotracer injection, dynamic acquisition over 20–30 min (20 s per frame, 128 × 128 matrix) serves to reveal the progression of lymphatic flow and to distinguish first tier from second-tier lymph nodes. Statics: large field of view gamma camera, high-resolution collimator, 256 × 256 matrix. Static images can be repeated at 2 h and, again at 4–6 h after injection or even just before operation.

Breast Cancer: Images obtained in both the anterior and lateral projections, prone position imaging with the breast hanging down (gravity “pull”) moves the injection site scatter away from the chest and axilla, unmasking any SNs close to the injection site. Tape traction.

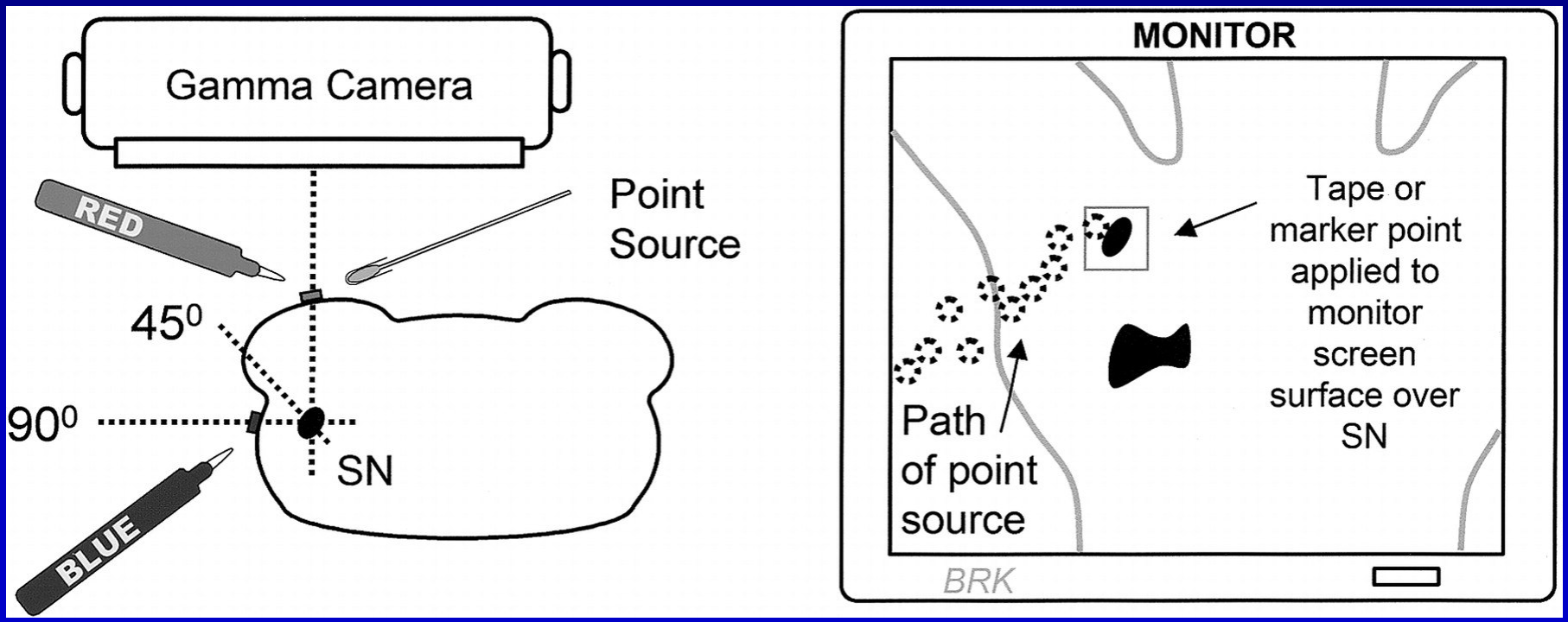
Lympho-Scintigraphy - Imaging

Once the SNs are visualized, the patient's body is marked by using a triangulation technique, which allows the surgeon to deduce the actual three dimensional position of the SN in the patient's body by extrapolating from surface markings on the patient. The site of these nodes is marked on the overlying skin, thus localizing the nodes for the surgeon.

To facilitate topographic localization, a 57Co flood source (122 keV) can be used for simultaneous transmission imaging, or the body silhouette can be outlined by moving a radioactive point source along the contour of the body while recording the scan.

Failure to visualize an SN alerts the surgeon that blue dye and traditional LND might be needed.

Lympho-Scintigraphy - Technique



Intra-Operative Localisation

The gamma probe moved carefully and slowly, SN has higher count than that of the background (at least 10:1 intraoperatively). Any lymph node whose counting rate is at least 20% of the counting rate of the hottest node in the basin should be considered an additional sentinel node. After all sentinel nodes are removed for histopathologic examination, residual radioactivity should be <10% of the counting rate in the hottest node.

Blue dye : used during surgery to delineate the SN, injecting the dye into the tissues surrounding the primary lesion (or less commonly into the skin or areola) and then quickly dissecting along lymphatic pathways to the SN, addition of dye has increased the success rate for finding SNs, has lowered the false-negative rate, and tended to increase the number of nodes harvested, disadvantage: time pressures inherent in the technique as well as the added dissection that it entails if performed as a primary guide to finding the SN.