Revised 2018 (Resolution 8)*

ACR–SPR–SSR PRACTICE PARAMETER FOR THE PERFORMANCE OF DUAL-ENERGY X-RAY ABSORPTIOMETRY (DXA)

PREAMBLE

This document is an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. Practice Parameters and Technical Standards are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care[1]. For these reasons and those set forth below, the American College of Radiology and our collaborating medical specialty societies caution against the use of these documents in litigation in which the clinical decisions of a practitioner are called into question.

The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by the practitioner in light of all the circumstances presented. Thus, an approach that differs from the guidance in this document, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in this document when, in the reasonable judgment of the practitioner, such course of action is indicated by the condition of the patient, limitations of available resources, or advances in knowledge or technology subsequent to publication of this document. However, a practitioner who employs an approach substantially different from the guidance in this document is advised to document in the patient record information sufficient to explain the approach taken.

The practice of medicine involves not only the science, but also the art of dealing with the prevention, diagnosis, alleviation, and treatment of disease. The variety and complexity of human conditions make it impossible to always reach the most appropriate diagnosis or to predict with certainty a particular response to treatment. Therefore, it should be recognized that adherence to the guidance in this document will not assure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient to deliver effective and safe medical care. The sole purpose of this document is to assist practitioners in achieving this objective.

[1] Iowa Medical Society and Iowa Society of Anesthesiologists v. Iowa Board of Nursing, ___ N.W.2d ___ (Iowa 2013) Iowa Supreme Court refuses to find that the *ACR Technical Standard for Management of the Use of Radiation in Fluoroscopic Procedures* (Revised 2008) sets a national standard for who may perform fluoroscopic procedures in light of the standard's stated purpose that ACR standards are educational tools and not intended to establish a legal standard of care. See also, Stanley v. McCarver, 63 P.3d 1076 (Ariz. App. 2003) where in a concurring opinion the Court stated that "published standards or guidelines of specialty medical organizations are useful in determining the duty owed or the standard of care applicable in a given situation" even though ACR standards themselves do not establish the standard of care.

I. INTRODUCTION

This practice parameter was revised collaboratively by the American College of Radiology (ACR), the Society for Pediatric Radiology (SPR), and the Society of Skeletal Radiology (SSR).

Dual-energy X-ray absorptiometry (DXA) [1] is a clinically proven, accurate, and reproducible method of measuring bone mineral density (BMD) in the lumbar spine, proximal femur, forearm, and whole body [2-7]. It is used primarily in the diagnosis and management of osteoporosis and other disease states characterized by abnormal BMD, as well as to monitor response to therapy for these conditions [8,9].

DXA may also be used to measure whole-body composition [10-12], including nonbone lean mass (LM) and fat mass (FM). DXA-measured LM and FM may be helpful in assessing a number of conditions, including sarcopenia and cachexia.

This practice parameter outlines the principles of performing high-quality DXA.

II. INDICATIONS AND CONTRAINDICATIONS

DXA measurement of BMD, LM, or FM is indicated whenever a clinical decision is likely to be directly influenced by the result of the test [13].

A. Indications for DXA include, but are not limited to, individuals with suspected abnormal BMD, LM, or FM, including [2,6,7,14-23]:

1. All women aged 65 years and older and men aged 70 years and older (asymptomatic screening)

2. All postmenopausal women younger than 65 years and men younger than 70 years who have risk factors for osteoporosis including:

    a. A history of fracture of the wrist, hip, spine, or proximal humerus with minimal or no trauma, excluding pathologic fractures
    b. Family history of osteoporotic fracture
    c. Low body mass (less than 127 lbs or 57.6 kg)
    d. Current use of cigarettes
    e. Excessive use of alcohol
    f. Loss of height, thoracic kyphosis

3. Individuals of any age with findings suggestive of demineralization or fragility fractures on imaging studies such as radiographs, computed tomography (CT), or magnetic resonance imaging (MRI)

4. Individuals receiving (or expected to receive) glucocorticoid therapy for more than 3 months

5. Individuals beginning or receiving long-term therapy with medications known to adversely affect BMD (eg, anticonvulsant drugs, androgen deprivation therapy, aromatase inhibitor therapy**,** or chronic heparin)

6. Although proton pump inhibitors (PPIs) may be associated with an increased risk of fragility fractures, routine or screening BMD is not recommended in patients receiving PPIs in the absence of other risk factors [24]

7. Individuals with an endocrine disorder known to adversely affect BMD (eg, hyperparathyroidism, hyperthyroidism, or Cushing's syndrome)

8. Postpubertal hypogonadal males with surgically or chemotherapeutically induced castration

9. Individuals with medical conditions associated with abnormal BMD, such as:

    a. Chronic renal failure
    b. Rheumatoid arthritis and other inflammatory arthritides
    c. Eating disorders, including anorexia nervosa and bulimia
    d. Gastrointestinal malabsorption or sprue
    e. Osteomalacia
    f. Acromegaly, chronic alcoholism, or established cirrhosis
    g. Multiple myeloma
    h. Gastric bypass for obesity. The accuracy of DXA in these patients might be affected by obesity
    i. Organ Transplantation
    j. Prolonged immobilization
    k. Prolonged poor nutrition

10. Individuals being monitored to:

    a. Assess the effectiveness of osteoporosis drug therapy [25]
    b. Follow-up medical conditions associated with abnormal BMD

11. DXA may be indicated as a tool to measure regional and whole body fat and LM (eg, for patients with malabsorption, cancer, or eating disorders) [21,26-29]

B. Pediatric Indications and Considerations

Indications for performing BMD examinations and subsequent assessment in children differ significantly from those in adults. Interpreting BMD measurements in children is complicated by the growing skeleton. DXA is unable to take into account changes in body and skeletal size during growth, limiting its usefulness in longitudinal studies. For example, an increase in DXA-measured areal BMD in the spine is more likely a reflection of the change of vertebral size than a change in BMD. Because quantitative computed tomography (QCT) can assess both volume and density of bone in the axial and appendicular skeleton, it may be more useful than DXA in children. Because of its lower radiation dose, peripheral QCT, which assesses the extremities, may be preferable to central QCT in pediatric patients.

In children and adolescents, BMD measurement is indicated whenever a clinical decision is likely to be directly influenced by the result of the test. Indications for DXA include, but are not limited to [26]:

1. Individuals receiving (or expected to receive) glucocorticoid therapy for more than 3 months

2. Individuals receiving radiation or chemotherapy for malignancy

3. Individuals with an endocrine disorder known to adversely affect BMD (eg, hyperparathyroidism, hyperthyroidism, growth hormone deficiency, or Cushing's syndrome)

4. Individuals with bone dysplasias known to have excessive fracture risk (osteogenesis imperfecta, osteopetrosis) or high bone density such as with prolonged exposure to fluoride

5. Individuals with medical conditions that could alter BMD, such as:

    a. Chronic renal failure
    b. Rheumatoid arthritis and other inflammatory arthritides
    c. Eating disorders, including anorexia nervosa and bulimia
    d. Organ transplantation
    e. Prolonged immobilization
    f. Gastrointestinal malabsorption, including that related to Cystic Fibrosis
    g. Sprue

h. Inflammatory bowel disease
i. Malnutrition
j. Osteomalacia
k. Vitamin D deficiency
l. Acromegaly
m. Cirrhosis
n. HIV infection
o. Prolonged exposure to fluorides

C. Contraindications

There are no absolute contraindications to performing DXA [30]. However, a DXA examination may be of limited value or require modification of the technique or rescheduling of the examination in some situations, including:

1. Recently administered oral contrast or radionuclides

2. Pregnancy

3. Severe degenerative changes or fracture deformity in the measurement area

4. Implants, hardware, devices, or other foreign material in the measurement area

5. The patient's inability to attain correct position and/or remain motionless for the measurement

6. Extremes of high or low body mass index that may adversely affect the ability to obtain accurate measurements. QCT may be a desirable alternative in these individuals [31-33]

For the pregnant or potentially pregnant patient, see the ACR–SPR Practice Parameter for Imaging Pregnant or Potentially Pregnant Adolescents and Women with Ionizing Radiation [34].

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

For physician, Qualified Medical Physicist, registered radiologist assistant, and radiologic technologist qualifications see the ACR–SPR Practice Parameter for General Radiography [35]. Additional specific qualifications and responsibilities include:

A. Physician [36-38]

The examination must be performed under the supervision of and be interpreted by a licensed physician with the following qualifications:

Knowledge and understanding of bone structure, metabolism, and osteoporosis

1. Documented training in and understanding of the physics of X-ray absorption and radiation protection, including the potential hazards of radiation exposure to both patients and personnel and the monitoring requirements

2. Knowledge and understanding of the process of DXA data and image acquisition, including proper patient positioning and placement of regions of interest, and artifacts and anatomic abnormalities that may falsely increase or decrease measured values

3. Knowledge and understanding of the analysis and reporting of DXA, including, but not limited to, BMD, T-score, Z-score, WHO fracture risk assessment tool (FRAX®), and the WHO classification system

4. Knowledge and understanding of the criteria for comparison of serial measurements, including limitations of comparing measurements made by different techniques and different devices, the rationale behind precision testing, and the statistical significance of serial changes in BMD

5. Awareness of other bone densitometry techniques, including QCT, peripheral QCT, peripheral DXA, and quantitative ultrasound (QUS), to fulfill a consultative role in recommending further studies, future measurements, or diagnostic procedures to confirm suspected abnormalities seen on DXA images

6. When performing DXA for the assessment of body composition, the physician should have additional knowledge and understanding of:

    a. Analysis and reporting of DXA, including but not limited to LM, FM, appendicular lean mass (ALM), and visceral adipose tissue (VAT)
    b. Other modalities used to assess body composition, including CT, MRI, QUS, bioelectrical impedance analysis, and anthropomorphic analysis

The supervising physician must be responsible for overseeing the DXA facility and its equipment quality control program. The physician accepts final responsibility for the quality of all DXA examinations.

The physician's continuing medical education should be in accordance with the ACR Practice Parameter for Continuing Medical Education (CME) [39].

B. Radiologic and Nuclear Medicine Technologist

The examination must be performed by a technologist with the following qualifications and responsibilities:

1. Responsibility for patient comfort and safety, preparing and properly positioning the patient, placement of regions of interest for BMD measurements, monitoring the patient during the measurements, and obtaining the measurements prescribed by the supervising physician

2. Documented formal training in the use of the DXA equipment, including all manufacturer-specified quality assurance procedures [40]

3. Knowledge of and familiarity with the manufacturer's operator manual for the specific scanner model being used

4. Responsibility for determining precision error and calculating least significant change (LSC) (see section VII. D)

5. State licensure and/or certification, if required. Organizations providing certification in bone densitometry include the American Registry of Radiologic Technologists (ARRT), the Nuclear Medicine Technology Certification Board (NMTCB), and the International Society for Clinical Densitometry (ISCD)

The technologist's continuing medical education should be in accordance with the national registry or state licensure requirements where applicable.

IV. SPECIFICATIONS OF THE EXAMINATION

A. The written or electronic request for a DXA examination should provide sufficient information to demonstrate the medical necessity of the examination and allow for its proper performance and interpretation.

Documentation that satisfies medical necessity includes 1) signs and symptoms and/or 2) relevant history (including known diagnoses). Additional information regarding the specific reason for the examination or a provisional diagnosis would be helpful and may at times be needed to allow for the proper performance and interpretation of the examination.

The request for the examination must be originated by a physician or other appropriately licensed health care provider. The accompanying clinical information should be provided by a physician or other appropriately licensed health care provider familiar with the patient's clinical problem or question and consistent with the state scope of practice requirements. (ACR Resolution 35, adopted in 2006 – revised in 2016, Resolution 12-b)

B. A history should be obtained from the patient regarding risk factors (as listed in section III), and prior surgery that could potentially affect the accuracy of measurements. Questionnaires can be found on www.iscd.org or www.nof.org.

C. Standard DXA examination in adults should, at a minimum, consist of a posteroanterior scan of the lumbar spine and scan of either hip [6,41-44]. However, imaging of both hips would provide information on the lowest hip BMD, and if in the future one hip becomes unavailable to utilize (eg, fracture and/or surgery), there would be comparison information available for the unaffected hip to determine BMD change. In instances where this is not feasible (extensive abdominal aortic calcification, degenerative disease of the lumbar spine or hip, scoliosis, fractures, implants), alternate sites can be used for evaluating the patient, including the other hip, nondominant forearm, or whole body [45]. DXA of the nondominant forearm may be useful in individuals who exceed the weight limit of the DXA table and in individuals with hyperparathyroidism [6].

D. In children and adolescents, a DXA examination should consist of an examination of the lumbar spine and whole body [6,46-49]. What is acquired may vary with the indication. In individuals with quadriplegic cerebral palsy, often with spinal fusion hardware and proximal femoral hardware or hip point contracture, the distal femur in the lateral position can be used for measurement of BMD and follow-up of therapy. The pediatric normative database for this technique is vendor specific [50-52]. The relationship of BMD to fracture risk in children is not clearly established [27,47].

E. DXA examination includes images of the areas where BMD is measured. If prior images (eg, radiographs, CT, MRI) of these anatomic areas are available, they should be reviewed to determine if specific sites should not be analyzed using DXA [53].

F. Positioning and soft-tissue-equivalent devices issued by the manufacturer must be used consistently and properly. Comfort devices, such as pillows under the head or knees, must not interfere with proper positioning and must never appear in the scan field.

G. For the lumbar spine, vertebrae may be excluded if there is a T-score difference of more than 1.0 compared to the adjacent vertebrae, or if there are focal structural abnormalities in or overlying the vertebra, such as fractures, previous surgery, degenerative changes, or other internal or external, artifacts. The remaining vertebrae (minimum of two levels) are used for diagnosis and monitoring. Diagnostic classification should not be made using a single vertebra.

H. For diagnosis in postmenopausal women and men aged 50 years and older, measured BMD values must be compared with those of the young adult reference population values, yielding a T-score that corresponds to a WHO diagnostic category [6]. For diagnosis in children, premenopausal women, and men younger than 50 years, measured BMD values must be compared with population-specific age-matched values, yielding a Z-score [6]. Typically, Z-scores of −2 or lower are considered to be below the expected range for age.

I. For diagnosis in children and adolescents, measured BMD values must be compared to a normative pediatric database yielding a gender-specific Z-score. An ethnicity-specific database should be used if available and adjustment for height when possible. BMD values and Z-scores for total-body less head region of interest are commonly reported. Reports should also include bone mineral content (BMC) [54]. Typically, Z-scores below −2 are considered abnormal.

J. When monitoring patients, comparison should be made to prior DXA examinations of the same skeletal site, region of interest, and area size. The precision error and LSC of the specific scanner(s) should be ascertained to determine if measured changes are statistically significant [6,55-58]. If the prior DXA examination was performed

on the same device (not just the same manufacturer model), quantitative comparison of the examinations can be performed. If the examination was on a different device, then comparison is qualitative unless a cross calibration calculation has been performed [40,59-61]. Comparability of scans, in order of decreasing validity, is as follows:

1. Previous examinations on the same well-maintained device

2. Previous examinations on another device with cross calibration calculation performed

3. Previous examinations on another device from the same manufacturer

4. Previous examinations on a device from another manufacturer (not recommended)

K. Vertebral fracture assessment (VFA) is a low-dose lateral image of the thoracic and lumbar spine that may be added to a standard DXA to determine whether vertebral fractures are present [63,64]. VFA should be considered in patients with height loss or back pain who have not been assessed by conventional radiographs, CT, or MRI. VFA is intended solely to identify whether spine compression is present and does not replace conventional diagnostic imaging for other purposes.

L. Trabecular Bone Score (TBS) is a method of obtaining quantitative data on bone texture from DXA spine images. TBS requires specialized software that measures relative pixel amplitude variations summing the squared gray-level differences [65]. TBS has been shown to improve fracture risk prediction using the FRAX tool. TBS-adjusted fracture risk calculation using the FRAX tool is especially valuable in patients with type 2 diabetes, who fracture at higher BMD levels than nondiabetics [66].

M. When assessing body composition using DXA, additional factors should be considered [21,28]:

1. Some patients may be too tall or too wide to be included in the scanned field. In patients who are too tall, part of the head can be excluded, or the patient can be imaged with bent knees. In patients who are too wide, half the body can be imaged, and the other half can be estimated because of symmetry.

2. Anything that alters body water can impact measurements. For instance, an overhydrated patient may result in a decreased LM and increased FM. Scans obtained soon after overnight fasting before the patient has consumed anything allow for most reproducible measurements.

3. When assessing muscle mass measurements, such as total LM/height2, arms LM + legs LM (ALM), ALM/total weight, and ALM/height2 are useful in detecting sarcopenia and other chronic conditions that affect LM.

4. Adiposity measurements, including VAT, subcutaneous adipose tissue, and FM index (FM/height2), may be used in evaluating patients with cancer, cachexia, and other chronic conditions that affect FM and distribution.

V. DOCUMENTATION

Reporting should be done in accordance with the ACR Practice Parameter for Communication of Diagnostic Imaging Findings **[**67**]**.

A. A permanent record must be maintained, and should include:

1. Patient identification, facility identification, examination date, image orientation, and unit manufacturer and model

2. Clinical notes or patient questionnaire containing pertinent history

3. Positioning, anatomical information, and/or technique settings needed for performing serial measurements

4. Printouts or their electronic equivalent of the images and regions of interest if provided by the scanner

B. For postmenopausal women and men aged 50 years and older, the reports should include the BMD (in g/cm²), T-score, and classification according to WHO criteria. One diagnostic category of normal, osteopenia (low bone mass), or osteoporosis is assigned to each patient based on the lowest T-score of the lumbar spine, total hip, femoral neck, or radius (radius 33%, radius 1/3). WHO classification is assigned only to the lowest T-score, not to each site evaluated. Osteoporosis by WHO category is not further defined as mild, moderate, or severe. The only exception is a combination of a T-score consistent with osteoporosis and a fragility fracture that can be diagnosed as "severe osteoporosis."

C. A statement about fracture risk is recommended, if appropriate. The most commonly used model for calculating absolute risk is the WHO Fracture risk assessment tool (FRAX® tool). The FRAX® tool provides 10-year risk of hip fracture and global fracture (hip, spine, forearm, humerus), has been FDA approved and may be applied in men or women who meet criteria [68]. In the United States, FRAX is typically not reported in patients already receiving therapy for osteoporosis, in patients with known vertebral or hip fractures, or in patients younger than 50 years. Other considerations for the use of FRAX are available in the International Society for Clinical Densitometry Official Position Statement on FRAX [69].

D. For premenopausal women and men younger than 50 years, the BMD and Z-score should be reported for each skeletal site examined. The WHO classification does not apply to these individuals (except for women in menopausal transition). Z-scores above −2.0 are considered within the expected range for their age. Individuals with Z-scores of −2.0 and lower are considered to have low bone density for their age.

E. For children and adolescents, T-scores should not be reported. The WHO classification does not apply; the terms "osteopenia" and "osteoporosis" should not be used when BMC or areal BMD Z-scores are less than or equal to −2. "Low bone mineral mass or bone mineral density" is the preferred terminology for pediatric DXA reports [70].

F. For all examinations, the report should indicate whether artifacts or other technical issues may have influenced the reported measurements of BMD.

G. A statement comparing the current study to prior available studies should include a statement of whether any changes in measured BMD are statistically significant. Recommendations for, and the timing of, a follow-up DXA scan may also be included.

H. When appropriate, suggestions for further imaging (eg, radiography, CT, or MRI) or other ancillary tests should be provided.

VI. EQUIPMENT SPECIFICATIONS

Various equipment designs that can accurately and reproducibly measure BMD using DXA are available. The equipment should provide the following:

1. Normal young adult and age-matched reference population values matched for sex and applicable to the equipment being used. Some devices also provide reference values matched for ethnicity and body weight.

2. Labeled images of the anatomic site measured and measurement results. These should be recorded permanently for patient records.

3. Precision errors of measurement of a phantom or standard that do not exceed the specifications or recommendations of the manufacturer and are less than 1%. In vitro (phantom) precision should not be equated with in vivo (patient) precision, as the role of the technologist in patient positioning and scan analysis is critical.

A phantom or other standard must be measured according to the manufacturer's recommendations in order to monitor instrument calibration.

VII. EQUIPMENT QUALITY CONTROL

DXA equipment quality control is especially important for monitoring the effectiveness of therapy or progression of disease [40].

A. Each DXA facility should have documented policies and procedures for evaluating the effective management, safety, and operation of DXA equipment. The quality control program should be designed in consultation with a Qualified Medical Physicist to minimize risks for patients, personnel, and the public and to maximize the quality of the diagnostic information.

B. At installation of a DXA unit, an environmental radiation safety survey should be conducted by a Qualified Medical Physicist. The survey should include any additional evaluation as required by state regulations.

C. Quality control procedures should be performed and permanently recorded by a trained technologist. These procedures are generally required at least 3 days a week and always before the first patient measurement of the day. They should be interpreted immediately upon completion, according to the guidelines provided by the manufacturer, to ensure proper system performance.

If a problem is detected, according to manufacturer guidelines, the service representative should be notified and patients should not be examined until the equipment has been cleared for use.

D. Each facility should determine its precision error and calculate LSC. If a facility has more than one DXA technologist, these values should represent an average of pooled data from all technologists.

E. Upon replacement of the DXA unit, precision error and LSC should be cross calibrated and recalculated [71].

VIII. RADIATION SAFETY IN IMAGING

Radiologists, medical physicists, registered radiologist assistants, radiologic technologists, and all supervising physicians have a responsibility for safety in the workplace by keeping radiation exposure to staff, and to society as a whole, "as low as reasonably achievable" (ALARA) and to assure that radiation doses to individual patients are appropriate, taking into account the possible risk from radiation exposure and the diagnostic image quality necessary to achieve the clinical objective. All personnel that work with ionizing radiation must understand the key principles of occupational and public radiation protection (justification, optimization of protection and application of dose limits) and the principles of proper management of radiation dose to patients (justification, optimization and the use of dose reference levels)
http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1578_web-57265295.pdf.

Nationally developed guidelines, such as the ACR's Appropriateness Criteria®, should be used to help choose the most appropriate imaging procedures to prevent unwarranted radiation exposure.

Facilities should have and adhere to policies and procedures that require varying ionizing radiation examination protocols (plain radiography, fluoroscopy, interventional radiology, CT) to take into account patient body habitus (such as patient dimensions, weight, or body mass index) to optimize the relationship between minimal radiation dose and adequate image quality. Automated dose reduction technologies available on imaging equipment should be used whenever appropriate. If such technology is not available, appropriate manual techniques should be used.

Additional information regarding patient radiation safety in imaging is available at the Image Gently® for children (www.imagegently.org) and Image Wisely® for adults (www.imagewisely.org) websites. These advocacy and awareness campaigns provide free educational materials for all stakeholders involved in imaging (patients, technologists, referring providers, medical physicists, and radiologists).

Radiation exposures or other dose indices should be measured and patient radiation dose estimated for representative examinations and types of patients by a Qualified Medical Physicist in accordance with the applicable ACR technical standards. Regular auditing of patient dose indices should be performed by comparing the facility's dose information with national benchmarks, such as the ACR Dose Index Registry, the NCRP Report No. 172, Reference Levels and Achievable Doses in Medical and Dental Imaging: Recommendations for the United States or the Conference of Radiation Control Program Director's National Evaluation of X-ray Trends. (ACR Resolution 17 adopted in 2006 – revised in 2009, 2013, Resolution 52).

IX. QUALITY CONTROL AND IMPROVEMENT, SAFETY, INFECTION CONTROL, AND PATIENT EDUCATION

Policies and procedures related to quality, patient education, infection control, and safety should be developed and implemented in accordance with the ACR Policy on Quality Control and Improvement, Safety, Infection Control, and Patient Education appearing under the heading *Position Statement on QC & Improvement, Safety, Infection Control, and Patient Education* on the ACR website (https://www.acr.org/Clinical-Resources/Practice-Parameters-and-Technical-Standards).

Equipment performance monitoring should be in accordance with manufacturer's recommendations and applicable aspects of the ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Radiographic Equipment [72].

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