**Bone marrow aspiration and biopsy: Indications and technique**

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Literature review current through:**Jan 2020. |**This topic last updated:**Jan 31, 2020.**

**INTRODUCTION**Bone marrow examination is useful in the diagnosis and staging of hematologic disease, as well as in the assessment of overall bone marrow cellularity. Because of easy accessibility, aspiration, biopsy, and culture of the bone marrow may also play a role in the assessment of patients with fever of undetermined origin as well as in the diagnosis of various storage and infiltrative disorders.

The indications, contraindications, technique, and complications of bone marrow aspiration and biopsy will be reviewed here [[1](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/1)]. Evaluation of bone marrow aspirates and biopsies is presented separately. (See ["Evaluation of bone marrow aspirate smears"](https://www-uptodate-com.ermg.femh.org.tw/contents/evaluation-of-bone-marrow-aspirate-smears?search=bone+marrow+Aspiration&topicRef=4436&source=see_link).)

**BACKGROUND INFORMATION**The bone marrow is one of the most widely distributed organs in the human body. It is the principal site of blood formation beginning at the time of birth, at which time all bone cavities are filled with hematopoietic tissue. (See ["Overview of hematopoietic stem cells", section on 'Bone marrow anatomy and microenvironment'](https://www-uptodate-com.ermg.femh.org.tw/contents/overview-of-hematopoietic-stem-cells?sectionName=BONE+MARROW+ANATOMY+AND+MICROENVIRONMENT&search=bone+marrow+Aspiration&topicRef=4436&anchor=H2&source=see_link#H2).)

By adolescence, active marrow is usually only found in the cavities of axial bones (sternum, ribs, vertebrae, clavicles, scapulae, skull, pelvis, and the proximal ends of the femurs and humeri) [[2,3](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/2,3)]. Overall bone marrow cellularity approximates 100 percent at birth and declines with time, paralleling an age-associated reduction in hematopoietic activity. Accordingly, bone marrow cellularity in the adult is approximately 50 percent, with the remainder of the marrow being composed of adipose tissue ([picture 1](https://www-uptodate-com.ermg.femh.org.tw/contents/image?imageKey=HEME%2F68384&topicKey=HEME%2F4436&search=bone+marrow+Aspiration&rank=1%7E150&source=see_link)). (See ["Evaluation of bone marrow aspirate smears", section on 'Estimation of cellularity and myeloid to erythroid ratio'](https://www-uptodate-com.ermg.femh.org.tw/contents/evaluation-of-bone-marrow-aspirate-smears?sectionName=Estimation+of+cellularity+and+myeloid+to+erythroid+ratio&search=bone+marrow+Aspiration&topicRef=4436&anchor=H8&source=see_link#H8).)

Under physiologic conditions, all sites of hematopoiesis tend to exhibit uniform cellularity and cell lineage proportions. Thus, generalizations can be made regarding overall hematopoiesis from the evaluation of bone marrow at a single site. In most hematologic disorders, study of bone marrow at multiple sites has not been shown to improve diagnostic accuracy [[2](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/2)]. Exceptions include malignancies that may have patchy marrow involvement (eg, multiple myeloma, lymphoma, metastatic disease), requiring either larger specimens or specimens from multiple sites. (See ['Adequacy of the biopsy specimen'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H12) below.)

**INDICATIONS**The decision to perform a bone marrow evaluation must be made after the critical assessment of pertinent information available from the history, physical, and laboratory studies, including a review of the complete blood count (CBC) and examination of the peripheral blood smear. As noted above, bone marrow examination is a useful tool in the diagnosis and staging of various hematologic diseases and in the assessment of bone marrow cellularity, cellular morphology, and maturation. Highly specialized testing, such as cytogenetic, immunophenotypic, and molecular analyses, can be performed on these specimens, and have become critically important in establishing certain diagnoses, especially the leukemias and lymphomas [[3,4](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/3,4)]. (See ["Clinical presentation and diagnosis of non-Hodgkin lymphoma", section on 'Studies on excised tissue'](https://www-uptodate-com.ermg.femh.org.tw/contents/clinical-presentation-and-diagnosis-of-non-hodgkin-lymphoma?sectionName=Studies+on+excised+tissue&search=bone+marrow+Aspiration&topicRef=4436&anchor=H25&source=see_link#H25) and ["Clinical manifestations, pathologic features, and diagnosis of acute myeloid leukemia", section on 'Diagnosis'](https://www-uptodate-com.ermg.femh.org.tw/contents/clinical-manifestations-pathologic-features-and-diagnosis-of-acute-myeloid-leukemia?sectionName=DIAGNOSIS&search=bone+marrow+Aspiration&topicRef=4436&anchor=H20&source=see_link#H20).)

In addition to accommodating blood cell formation, the bone marrow also houses a complex stromal complex, along with elements of the monocyte-macrophage system. These supporting cellular systems may also become involved in a number of systemic diseases. Accordingly, aspiration, biopsy, and culture of the bone marrow may have value in the assessment of patients with fever of undetermined origin and in the diagnosis of various storage and infiltrative diseases, in which the number and/or activity of these stromal cells may be deranged.

Most clinical scenarios require both bone marrow aspiration and biopsy for a complete hematologic evaluation. This is especially true when assessing overall bone marrow cellularity, determining patterns of marrow involvement, and searching for evidence of infiltration associated with Hodgkin and non-Hodgkin lymphoma, solid malignancies, or storage diseases. Accordingly, bone marrow aspiration is most often accompanied by biopsy [[5-8](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/5-8)].

Exceptions to this rule are circumstances in which a very specific clinical question can be answered via aspiration alone. An example might be in the diagnosis and follow-up of chronic myeloid leukemia (CML), as the diagnosis relies heavily on cytogenetic and molecular findings, as well as morphology, all of which can be obtained by aspiration or by sampling peripheral blood [[4](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/4)]. However, even this is controversial, as some cases of CML may be accompanied by fibrosis, which is best assessed on the biopsy specimen. Aspiration alone may be adequate for the initial diagnosis of acute myeloid leukemia (AML), as well as routine surveillance bone marrow examinations on these patients [[4](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/4)]. (See ["Remission criteria in acute myeloid leukemia and monitoring for residual disease"](https://www-uptodate-com.ermg.femh.org.tw/contents/remission-criteria-in-acute-myeloid-leukemia-and-monitoring-for-residual-disease?search=bone+marrow+Aspiration&topicRef=4436&source=see_link).)

Indications for bone marrow evaluation fall into several categories ([table 1](https://www-uptodate-com.ermg.femh.org.tw/contents/image?imageKey=HEME%2F66404&topicKey=HEME%2F4436&search=bone+marrow+Aspiration&rank=1%7E150&source=see_link)):

●Evaluation of unexplained anemia, leukopenia, thrombocytopenia, or pancytopenia. (See ["Approach to the adult with anemia", section on 'Bone marrow examination'](https://www-uptodate-com.ermg.femh.org.tw/contents/approach-to-the-adult-with-anemia?sectionName=Bone+marrow+examination&search=bone+marrow+Aspiration&topicRef=4436&anchor=H49&source=see_link#H49) and ["Laboratory evaluation of neutrophil disorders"](https://www-uptodate-com.ermg.femh.org.tw/contents/laboratory-evaluation-of-neutrophil-disorders?search=bone+marrow+Aspiration&topicRef=4436&source=see_link) and ["Approach to the adult with unexplained thrombocytopenia", section on 'Hematologist referral/consultation'](https://www-uptodate-com.ermg.femh.org.tw/contents/approach-to-the-adult-with-unexplained-thrombocytopenia?sectionName=Hematologist+referral%2Fconsultation&search=bone+marrow+Aspiration&topicRef=4436&anchor=H35&source=see_link#H35) and ["Approach to the adult with pancytopenia"](https://www-uptodate-com.ermg.femh.org.tw/contents/approach-to-the-adult-with-pancytopenia?search=bone+marrow+Aspiration&topicRef=4436&source=see_link).)

●Evaluation of unexplained elevations in peripheral blood counts (eg, polycythemia, thrombocytosis, leukocytosis). (See ["Diagnostic approach to the patient with polycythemia"](https://www-uptodate-com.ermg.femh.org.tw/contents/diagnostic-approach-to-the-patient-with-polycythemia?search=bone+marrow+Aspiration&topicRef=4436&source=see_link) and ["Approach to the patient with thrombocytosis"](https://www-uptodate-com.ermg.femh.org.tw/contents/approach-to-the-patient-with-thrombocytosis?search=bone+marrow+Aspiration&topicRef=4436&source=see_link) and ["Approach to the patient with neutrophilia"](https://www-uptodate-com.ermg.femh.org.tw/contents/approach-to-the-patient-with-neutrophilia?search=bone+marrow+Aspiration&topicRef=4436&source=see_link).)

●Diagnosis and staging of lymphoma or solid tumors. (See ["Clinical presentation and diagnosis of non-Hodgkin lymphoma", section on 'Bone marrow examination'](https://www-uptodate-com.ermg.femh.org.tw/contents/clinical-presentation-and-diagnosis-of-non-hodgkin-lymphoma?sectionName=Bone+marrow+examination&search=bone+marrow+Aspiration&topicRef=4436&anchor=H29&source=see_link#H29) and ["Pathobiology and staging of small cell carcinoma of the lung", section on 'Staging workup'](https://www-uptodate-com.ermg.femh.org.tw/contents/pathobiology-and-staging-of-small-cell-carcinoma-of-the-lung?sectionName=Staging+workup&search=bone+marrow+Aspiration&topicRef=4436&anchor=H10&source=see_link#H10).)

●Diagnosis and evaluation of plasma cell disorders and leukemias. (See ["Multiple myeloma: Clinical features, laboratory manifestations, and diagnosis", section on 'Bone marrow examination'](https://www-uptodate-com.ermg.femh.org.tw/contents/multiple-myeloma-clinical-features-laboratory-manifestations-and-diagnosis?sectionName=Bone+marrow+examination&search=bone+marrow+Aspiration&topicRef=4436&anchor=H18&source=see_link#H18) and ["Clinical manifestations, pathologic features, and diagnosis of acute myeloid leukemia", section on 'Bone marrow biopsy and aspirate'](https://www-uptodate-com.ermg.femh.org.tw/contents/clinical-manifestations-pathologic-features-and-diagnosis-of-acute-myeloid-leukemia?sectionName=Bone+marrow+biopsy+and+aspirate&search=bone+marrow+Aspiration&topicRef=4436&anchor=H14&source=see_link#H14).)

●Evaluation of iron metabolism and stores when routine laboratory testing is inadequate.

●Evaluation of suspected deposition and storage diseases (eg, amyloidosis, Gaucher disease). (See ["Pathogenesis of immunoglobulin light chain (AL) amyloidosis and light and heavy chain deposition diseases", section on 'Pathogenesis'](https://www-uptodate-com.ermg.femh.org.tw/contents/pathogenesis-of-immunoglobulin-light-chain-al-amyloidosis-and-light-and-heavy-chain-deposition-diseases?sectionName=PATHOGENESIS&search=bone+marrow+Aspiration&topicRef=4436&anchor=H6&source=see_link#H6) and ["Gaucher disease: Pathogenesis, clinical manifestations, and diagnosis", section on 'Diagnosis'](https://www-uptodate-com.ermg.femh.org.tw/contents/gaucher-disease-pathogenesis-clinical-manifestations-and-diagnosis?sectionName=DIAGNOSIS&search=bone+marrow+Aspiration&topicRef=4436&anchor=H22&source=see_link#H22).)

●Evaluation of fever of undetermined origin, suspected mycobacterial, fungal, or parasitic infections, or granulomatous diseases [[9-13](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/9-13)]. (See ["Approach to the adult with fever of unknown origin", section on 'Biopsy'](https://www-uptodate-com.ermg.femh.org.tw/contents/approach-to-the-adult-with-fever-of-unknown-origin?sectionName=Biopsy&search=bone+marrow+Aspiration&topicRef=4436&anchor=H20&source=see_link#H20).)

●Evaluation of unexplained splenomegaly.

●Confirmation that the bone marrow is normal in a potential allogeneic hematopoietic cell donor in selected patients (rarely needed). (See ["Donor selection for hematopoietic cell transplantation"](https://www-uptodate-com.ermg.femh.org.tw/contents/donor-selection-for-hematopoietic-cell-transplantation?search=bone+marrow+Aspiration&topicRef=4436&source=see_link).)

**CONTRAINDICATIONS**The only absolute contraindications to performing a bone marrow biopsy are the presence of severe hemophilia, severe disseminated intravascular coagulopathy, or other related severe bleeding disorders. Thrombocytopenia, regardless of severity, is not a contraindication [[14,15](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/14,15)]. However, depending on the circumstances, platelet transfusion to insure a platelet count >20,000/microL may be warranted prior to the procedure [[16](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/16)]. (See ["Clinical and laboratory aspects of platelet transfusion therapy", section on 'Preparation for an invasive procedure'](https://www-uptodate-com.ermg.femh.org.tw/contents/clinical-and-laboratory-aspects-of-platelet-transfusion-therapy?sectionName=Preparation+for+an+invasive+procedure&search=bone+marrow+Aspiration&topicRef=4436&anchor=H558384448&source=see_link#H558384448).)

Most hematologists do not consider therapeutic anticoagulation to be an important risk factor for bleeding following bone marrow biopsy, although practice patterns in this regard vary widely. As an example, an email survey of members of the Australasian Society of Thrombosis and Haemostasis and the Hematology Society of Australia and New Zealand asked hematologists about their current approaches to performing bone marrow biopsy among thrombocytopenic or anticoagulated patients. Results of this informal survey included the following [[17](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/17)]:

●In thrombocytopenic patients, 48 percent did not transfuse platelets, 49 percent transfused platelets only in selected patients, and 3 percent transfused platelets routinely.

●In anticoagulated patients, 13 percent performed the biopsy irrespective of the INR, 51 percent performed the biopsy if the INR was not above the therapeutic range, 18 percent performed the biopsy if the INR was <2.0, and 18 percent stopped [warfarin](https://www-uptodate-com.ermg.femh.org.tw/contents/warfarin-drug-information?search=bone+marrow+Aspiration&topicRef=4436&source=see_link) or reversed anticoagulation before performing the biopsy.

There is little or no information concerning the risk of bleeding following bone marrow aspiration/biopsy in patients who are taking one or more antiplatelet agents. It is the general consensus that bone marrow aspiration/biopsy is a low-risk procedure and that the risk of thrombosis from stopping these agents prior to the biopsy is greater than the risk of bleeding if these agents are not stopped. (See ["Perioperative management of patients receiving anticoagulants", section on 'Estimating thromboembolic risk'](https://www-uptodate-com.ermg.femh.org.tw/contents/perioperative-management-of-patients-receiving-anticoagulants?sectionName=ESTIMATING+THROMBOEMBOLIC+RISK&search=bone+marrow+Aspiration&topicRef=4436&anchor=H3&source=see_link#H3) and ["Perioperative medication management", section on 'Medications affecting hemostasis'](https://www-uptodate-com.ermg.femh.org.tw/contents/perioperative-medication-management?sectionName=MEDICATIONS+AFFECTING+HEMOSTASIS&search=bone+marrow+Aspiration&topicRef=4436&anchor=H25&source=see_link#H25).)

Post-procedural bleeding, if any, is almost always controlled by manual application of pressure to the site. (See ['Bleeding'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H32) below.)

Patients with suspected multiple myeloma or other disorders associated with bone resorption should not undergo sternal bone marrow aspiration due to an increased risk of sternal perforation. Bone marrow biopsy of the sternum should **never** be attempted in any patient, due to the fragility of the bone at this site as well as its proximity to the heart and great vessels.

Precautions may need to be taken if there is skin infection or osteomyelitis in the area of proposed aspiration or biopsy, or if the patient is unable to remain still for the procedure. Several complications may accompany bone marrow aspiration or biopsy despite adherence to these precautions (see ['Complications'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H31) below).

**ADVANCE PREPARATION**A number of important issues need to be resolved before the procedure is undertaken, including choice of the biopsy site, use of premedications and the need for an assistant, as well as determining the need and preparation necessary for specialized tests to be performed on the marrow specimens.

**Deciding which tests are needed** — The tests that are obtained depend on the clinical scenario and the diagnoses that are being considered.

Before starting the procedure, decisions should be made about whether both an aspirate and biopsy are required, and if special samples are needed for additional tests (eg, cytogenetics, flow cytometry, special stains) ([table 2](https://www-uptodate-com.ermg.femh.org.tw/contents/image?imageKey=HEME%2F82481&topicKey=HEME%2F4436&search=bone+marrow+Aspiration&rank=1%7E150&source=see_link)). A discussion with the hematopathology laboratory should occur before the procedure is undertaken to make sure that the appropriate samples, sample collection vials, and tests have been agreed upon. As examples, cytogenetic testing requires live cells, ideally in culture medium (not formalin-fixed cells), and special stains may require more slides than are routinely prepared.

Signed informed consent must be obtained in advance from the patient, parent, or health care proxy, as appropriate.

**Timing of the procedure** — Obtaining the sample when laboratory personnel are available for discussion and optimal specimen handling is generally preferable. However, in certain cases it may be necessary to obtain the sample in off-hours. Examples may include obtaining a sample before glucocorticoids are administered to a patient with possible lymphoid malignancy. Importantly, however, treatment of the patient should **not** be delayed solely to obtain a better sample.

It is also preferable to have a complete blood count (CBC) with differential and blood smear that was obtained on the same day as the bone marrow sample, to allow identification of specific cells and to correlate the bone marrow cellularity with cytopenias in the peripheral blood.

**Choice of aspiration or biopsy site** — The iliac crest is the only site at which both aspiration and biopsy may be safely performed in the adult.

●The posterior superior iliac crest and spine ([figure 1](https://www-uptodate-com.ermg.femh.org.tw/contents/image?imageKey=HEME%2F78950&topicKey=HEME%2F4436&search=bone+marrow+Aspiration&rank=1%7E150&source=see_link)) is the favored site of examination in the adult, as well as in the child and in most infants. This site also provides the least discomfort to the patient compared with other sites.

●The anterior iliac crest ([figure 2](https://www-uptodate-com.ermg.femh.org.tw/contents/image?imageKey=HEME%2F51068&topicKey=HEME%2F4436&search=bone+marrow+Aspiration&rank=1%7E150&source=see_link)) may be used for bone marrow aspiration and biopsy in adults when access to the posterior iliac crest is limited (eg, the patient is unable to be moved for proper access to the chosen aspiration site, morbid obesity, skin diseases, or previous radiation) [[2,14](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/2,14)]. An initial attempt to sample the posterior iliac bone may be worthwhile, even in neonates.

●In selected cases, bone marrow may be obtained from the greater trochanter of the femur, individual vertebral bodies, or ribs. Such procedures, including open bone biopsies, are best obtained through surgical consultation, and may require CT guidance (see ['Surgical biopsy'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H21) below).

●Obtaining bone marrow from a site which has been previously irradiated is likely to yield suboptimal results, especially in terms of overall cellularity. Another site should be chosen if at all possible.

Bone marrow may be aspirated from the sternum in patients over 12 years of age ([figure 3](https://www-uptodate-com.ermg.femh.org.tw/contents/image?imageKey=HEME%2F53887&topicKey=HEME%2F4436&search=bone+marrow+Aspiration&rank=1%7E150&source=see_link)), although **biopsy at this site is contraindicated**because of its minimal thickness. Special care needs to be taken if this site is chosen for marrow aspiration, since penetration of the inner table of the sternum or penetration through a rib interspace may lead to fatal hemorrhage (see ['Complications'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H31)below).

In premature infants and some full-term infants, the iliac bone has not completely ossified, and an alternative bone (eg, the anterior portion of the tibia) should be used [[18](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/18)]. If the anterior tibia must be entered, it should only be used for aspiration and limited to infants younger than 18 months of age.

On occasion, it may not be possible to identify an aspiration/biopsy site because of the presence of excessive adipose tissue; surface landmarks may be difficult to identify and/or the available needle may not reach the bone surface (see ['Technique'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H15) below and ['Needle selection'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H10) below). If these maneuvers have failed, one solution is to perform the procedure using computed tomography (CT) guidance [[19](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/19)].

In cases in which the landmarks can be identified but the needle is too short, a trephine biopsy needle may be used for both the aspiration and biopsy. (See ['Needle selection'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H10) below.)

**Premedications** — The pain perceived by the patient during bone marrow aspiration and biopsy performed under local anesthesia is low to moderate, being approximately 3 on a 0 to 10 scale in one study [[20](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/20)] and 1.7 on a 0 to 5 scale in another [[21](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/21)]. While premedications, including anxiolytics or opiates, are not usually necessary [[22](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/22)], certain individuals with underlying dense bone structure, pain issues, or those with heightened anxiety may benefit from the use of such agents. It cannot be overstated that the quality of the specimen obtained may be vastly superior in a cooperative and comfortable patient.

In children with procedure phobias, the use of [lorazepam](https://www-uptodate-com.ermg.femh.org.tw/contents/lorazepam-drug-information?search=bone+marrow+Aspiration&topicRef=4436&source=see_link) under carefully controlled conditions can be very beneficial, producing both relaxation and antegrade amnesia; lorazepam or [tramadol](https://www-uptodate-com.ermg.femh.org.tw/contents/tramadol-drug-information?search=bone+marrow+Aspiration&topicRef=4436&source=see_link) may have a similar effect in adults with anxiety [[23-26](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/23-26)]. This can be particularly helpful if the child or anxious adult is likely to require multiple bone marrow evaluations over a period of time, as in the treatment of acute leukemia. A safe conscious sedation policy should be in place prior to using drugs such as benzodiazepines or opioids in patients of any age.

The use of inhaled [nitrous oxide](https://www-uptodate-com.ermg.femh.org.tw/contents/nitrous-oxide-drug-information?search=bone+marrow+Aspiration&topicRef=4436&source=see_link) and oxygen, an established combination used for pain management and sedation in certain gynecologic procedures and in sigmoidoscopy, is both well-tolerated and effective for use during bone marrow aspiration and biopsy; use of this agent may diminish the risk of prolonged sedation associated with benzodiazepine or opioid dosing [[27-29](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/27-29)]. However, given the limited nature of these studies, further research may be required before the use of nitrous oxide/oxygen is accepted into standard practice.

Any premedications should be administered in a timely fashion, prior to performing the procedure, in order to allow for the desired effects [[25,26](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/25,26)]. (See ["Procedural sedation in children outside of the operating room"](https://www-uptodate-com.ermg.femh.org.tw/contents/procedural-sedation-in-children-outside-of-the-operating-room?search=bone+marrow+Aspiration&topicRef=4436&source=see_link).)

**Use of an assistant** — Bone marrow aspirates and biopsies often clot within minutes of being obtained. During this time, the person performing the procedure may still be busy performing an aspiration or biopsy at the same or another site, reassuring the patient, or initiating local hemostasis. Ideally, bone marrow aspiration and biopsy be carried out with the help of a trained assistant who can either help prepare the slides and specimens or who assist in achieving adequate hemostasis following completion of the procedure.

**Needle selection** — Disposable aspiration and biopsy needles are preferred in order to guarantee sterility and sharpness, as well as to reduce procedure-related pain and "failure" rates [[30](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/30)]. All commercially available needles are acceptable for aspiration and biopsy of the iliac crest. For sternal aspiration, the needle should have a guard which screws securely to a selected portion of the needle in order to limit its penetration (see ['Sternal aspiration'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H19) below).

Occasionally, in obese or large patients, it may be necessary to use a trephine biopsy needle for both the aspiration and biopsy at the iliac crest, as this needle tends to be longer than a standard aspiration needle.

**Sequence of aspiration and biopsy** — Although the techniques used for obtaining bone marrow aspiration and biopsy samples have been fairly well standardized, there has been some debate as to the sequence of aspiration and biopsy:

●Prior studies have demonstrated artifactual reduction in overall cellularity of the bone marrow sample due to acute intramedullary hemorrhage in the biopsy specimen when aspiration was followed by biopsy [[31](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/31)]. This effect was shown to be overcome by obtaining a longer, deeper specimen which bypasses the aspiration site [[32](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/32)].

●Alternatively, biopsy followed by aspiration could lead to premature clotting of the aspirated specimen.

Despite these issues, it is generally felt that high quality specimens can be obtained, regardless of the order, provided that separate needles and separate sites (one to two centimeters apart along the iliac crest) are used for each procedure [[32](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/32)].

**Adequacy of the biopsy specimen** — Biopsies consisting mostly of cortical bone, cartilage, or muscle, without sufficient sampling of the medullary cavity are inadequate for proper evaluation. Most laboratories require a sample at least 5 mm in length. In some cases, more extensive sampling may be required.

Obtaining an adequate biopsy from a single site in a patient with non-Hodgkin lymphoma (NHL) has been deemed inadequate by a number of studies. (See ["Clinical presentation and diagnosis of non-Hodgkin lymphoma", section on 'Bone marrow examination'](https://www-uptodate-com.ermg.femh.org.tw/contents/clinical-presentation-and-diagnosis-of-non-hodgkin-lymphoma?sectionName=Bone+marrow+examination&search=bone+marrow+Aspiration&topicRef=4436&anchor=H29&source=see_link#H29).)

●An early study involving 282 patients with lymphoma and other neoplastic diseases revealed accurate diagnosis with unilateral biopsy in only 22 percent of patients with NHL, 43 percent of patients with Hodgkin lymphoma, and 36 percent of those with other neoplastic processes [[33](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/33)]. The investigators concluded that bilateral sampling could yield an additional 11 to 22 percent of positive biopsies.

●Another study, including 170 specimens from 145 patients, found that accurate diagnosis improved 26 percent when bilateral specimens were obtained [[34](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/34)].

●A third study of 260 patients with NHL revealed that 30 percent of positive marrows had unilateral involvement only, supporting the need for bilateral sampling [[35](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/35)].

However, adequate length of a unilateral biopsy may obviate the need for bilateral examination:

●In one study, a biopsy length of 19.5 mm was the smallest acceptable length, leading to a 50 percent chance of detecting bone marrow metastases [[36](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/36)].

●Another study concluded that one 20 mm-long specimen could obviate the need for bilateral bone marrow sampling in patients being evaluated for the presence of diffuse large B-cell NHL [[37](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/37)].

**TECHNIQUE**

**Materials** — The supplies necessary for a bone marrow biopsy and aspiration, with the exception of sterile gloves and vials for specific studies on the collected samples, are conventionally packaged in a single tray. The contents should include all of the following:

●Povidone-iodine antiseptic solution for cleansing the chosen site, along with the necessary drapes to maintain sterility at the site

●A 1 or 2 percent [lidocaine](https://www-uptodate-com.ermg.femh.org.tw/contents/lidocaine-drug-information?search=bone+marrow+Aspiration&topicRef=4436&source=see_link) solution for local anesthesia, along with a sterile syringe, a 23-gauge and a 21-gauge needle

●A number 11 scalpel blade for making the skin incision prior to inserting the aspiration and biopsy needles

●Sufficient quantities of sterile gauze and bandages to clean the biopsy site and to apply local pressure to insure hemostasis when the procedure has been completed

●A large selection of needles used for aspiration is available. A needle with a stylet that can be fixed in place initially and removed later is preferred. It is important to use a sharp needle, as well as one long enough to penetrate through the subcutaneous tissues and into the marrow cavity. A needle chosen for sternal aspiration should be shorter than one used for aspiration at the iliac crest, and should be equipped with a guard to insure controlled entrance into (and not beyond) the sternal marrow cavity (see ['Sternal aspiration'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H19) below).

●Jamshidi biopsy needle with stylet and a device (obturator) for removing the biopsy core from the needle without damage to the specimen.

**Posterior iliac crest** — Proper bone marrow aspiration and biopsy requires strict attention to detail. The following items should be completed in the order in which they appear:

●Administer any necessary premedications (anti-anxiolytics or pain medications) (see ['Premedications'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H8) above).

●The patient should be placed in either a prone or lateral decubitus position. In heavier patients, a lateral decubitus position with the knees pulled closer to the chest, or a prone position accompanied by pressure over the bone, may help to identify the landmarks by reducing the depth of the fat pad overlying the iliac crest [[38](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/38)].

●Examine the potential site for evidence of infection; palpate the posterior iliac crest and posterior superior iliac spine and locate these landmarks ([figure 1](https://www-uptodate-com.ermg.femh.org.tw/contents/image?imageKey=HEME%2F78950&topicKey=HEME%2F4436&search=bone+marrow+Aspiration&rank=1%7E150&source=see_link)) [[39](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/39)]. The anterior superior iliac spine should also be palpated and located, as the needle will be pointed in this direction once the bone has been entered ([figure 2](https://www-uptodate-com.ermg.femh.org.tw/contents/image?imageKey=HEME%2F51068&topicKey=HEME%2F4436&search=bone+marrow+Aspiration&rank=1%7E150&source=see_link)).

●Maintain a steady dialogue with the patient, explaining each step, alerting the patient to potential discomfort, with reassurance as needed.

●In the absence of local skin problems (eg, infection, induration, ulceration), the usual site for aspiration and biopsy is approximately three finger-widths from the midline and two finger-widths inferior to the iliac crest. Mark the chosen area by making an indentation in the skin with a coin, fingernail, or the end of a ballpoint pen with the writing tip retracted.

●Using sterile technique, protective clothing and gloves (and eye wear if necessary), the bone marrow tray should be first opened and organized for easy access to needed items. Needles, stylets, and plastic (not glass) syringes should be checked to ensure that they are intact and function properly.

●Cleanse the chosen area with povidone-iodine solution and drape a sterile field. Prepare the instruments.

●Anesthetize the skin and subcutaneous tissues with a 1 to 2 percent [lidocaine](https://www-uptodate-com.ermg.femh.org.tw/contents/lidocaine-drug-information?search=bone+marrow+Aspiration&topicRef=4436&source=see_link) solution using a 23-gauge needle; then anesthetize the periosteum by repeatedly injecting small amounts of lidocaine solution at different points on the surface of the bone with a 21-gauge needle. It is useful to anesthetize a dime-sized area of the periosteum surrounding the targeted location, as the aspiration and biopsy should be taken from slightly different adjacent sites.

●While waiting for the anesthetic to produce its effect, extra syringes for special studies (eg, flow cytometry, cytogenetics, and molecular studies) can be appropriately anticoagulated. Specimens for molecular studies should not contain heparin. The help of an assistant is invaluable.

●Once local anesthesia has been achieved, make a small (3 mm) skin incision with a scalpel blade at the site of insertion of the aspiration needle, in order to facilitate its entry and promote organized healing of the wound.

●Hold the bone marrow needle (with stylet in place) perpendicular to the skin at the previously marked point, and gently advance it to the periosteum. In order to be sure that the needle is entering correctly, the second and third fingers on the hand not being used to insert the needle should be placed on the iliac crest or spine and the needle inserted between them [[3](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/3)]. When the needle has been advanced to the periosteum, it should be pointed laterally in the direction of the anterior superior iliac spine on the same side ([figure 2](https://www-uptodate-com.ermg.femh.org.tw/contents/image?imageKey=HEME%2F51068&topicKey=HEME%2F4436&search=bone+marrow+Aspiration&rank=1%7E150&source=see_link)), rather than continuing in a perpendicular direction [[40](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/40)]. (See ['Bleeding'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H32) below.)

●Use a steady twisting back and forth motion. Do not twist more than 180 degrees to penetrate the periosteum and the cortical bone; a "give" is felt when the needle enters the marrow cavity. At the point of entry, the patient may express complaints of a deep-seated pain. It is important to alert the patient to this possibility ahead of time. Continue to advance the needle slightly to ensure that it is anchored into the bone.

●Remove the stylet, attach a 2 mL syringe to the aspiration needle, and again advise the patient that the aspiration may cause a brief period of pain.

●Aspirate 0.2 to 0.5 mL of marrow contents and remove the syringe. It may be necessary to attach additional syringes if many studies have been ordered. In general it is prudent to avoid aspirating more than 0.5 mL per syringe, as greater amounts may be prone to dilution of the bone marrow sample with peripheral blood or to clotting [[3](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/3)].

●The non-anticoagulated specimen should be handed to the assistant, who will assess the quality of the sample (ie, determine the presence or absence of grossly visible bone spicules) and prepare the various smears. If an assistant is not available, the sample should be used immediately to make a bone marrow aspirate smear and/or placed in an appropriate tube for later smear preparation. Anticoagulated specimens should be sent to the laboratory for further preparation and other tests (eg, cytogenetics, molecular studies, cultures, flow cytometry). The patient should be made aware of the need for multiple specimens at the outset, since each separate aspiration may be painful, despite fully adequate local anesthesia. (See ['Preparation of samples'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H22) below.)

●If aspiration attempts are not successful, reinsert the stylet (the needle may be rotated) and advance the needle a short distance; repeat attempts at aspiration with the syringe and suction. If multiple aspiration attempts are unsuccessful, an alternate site (eg, the other posterior iliac crest) may be approached with the same sterile strategy after the bone marrow biopsy has been obtained.

●Once it has been determined that the aspirate is satisfactory, reinsert the stylet, and remove the needle (with stylet in place) by using a similar twisting motion, and apply pressure to the site with a small gauze square until the bleeding stops.

●If a biopsy is necessary, prepare the Jamshidi needle and advance it into the cortical bone, using the same incision but a slightly different site, with a steady twisting movement until it is firmly lodged. This may require a greater amount of pressure than was used for the aspiration. Remove the stylet and with a rotating motion advance the needle another 15 to 20 mm.

●Redirect the needle tip and rotate it 360 degrees in both directions to separate the biopsy specimen from the surrounding marrow tissue. Following this step, the needle should be advanced a very short distance prior to removal. This step may prevent the specimen from being pulled out of the needle at the biopsy site.

●Remove the needle with a slight twisting motion, place a sterile dressing over the site, and apply pressure for several minutes until the bleeding stops. Once hemostasis is achieved, a bandage should be applied, and the patient should be instructed to lie supine for 10 or more minutes. Pressure dressings may be required in thrombocytopenic patients.

●Once the biopsy needle has been removed, the specimen may be extracted from the needle by inserting the obturator (or stylet) through the distal (cutting) end of the needle. The bone marrow biopsy can then be placed on a slide, where imprints ("touch prints") are made before the core specimen is further processed for cytologic investigations. This step is especially useful in situations where a bone marrow aspirate could not be obtained (see ['The dry tap'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H1277224) below) [[3](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/3)].

●Examine the biopsy specimen. If the specimen consists mostly of homogeneous, white material (cortical bone) or glistening tissue (cartilage), it may be necessary to attempt a second biopsy for a more satisfactory specimen. This should be done with a new biopsy needle, as the original needle may have been damaged by the process of inserting the obturator or stylet through the distal end of the biopsy needle.

●Prior to leaving the patient, the bone marrow aspiration/biopsy site(s) should be evaluated to assess for prolonged bleeding. This is minimized by applying a pressure dressing over the site(s), with the patient remaining recumbent, for at least 10 minutes.

**Anterior iliac crest** — Samples are taken from a site 2.5 to 5 cm posterior the anterior superior iliac spine and beneath the palpable lip of the iliac crest ([figure 2](https://www-uptodate-com.ermg.femh.org.tw/contents/image?imageKey=HEME%2F51068&topicKey=HEME%2F4436&search=bone+marrow+Aspiration&rank=1%7E150&source=see_link)) [[41](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/41)].

●The patient should be relaxed, comfortable, and in the supine position.

●Once a satisfactory site has been identified, the remainder of the procedure is identical to that for the posterior iliac crest. (See ['Posterior iliac crest'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H17) above.)

**Sternal aspiration** — This procedure should only be undertaken in patients more than 12 years old. Select a level of the sternum at either the second or third intercostal space ([figure 3](https://www-uptodate-com.ermg.femh.org.tw/contents/image?imageKey=HEME%2F53887&topicKey=HEME%2F4436&search=bone+marrow+Aspiration&rank=1%7E150&source=see_link)) [[14](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/14)]. Aspiration should be attempted only from the first part of the body of the sternum, or from the manubrium [[4](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/4)].

●The patient should be positioned in a semi-recumbent or supine position

●Ensure that the aspiration needle functions properly and that the guard is **securely** in place. The guard should be adjusted so that only 5 mm advancement of the needle is possible beyond the periosteum [[42](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/42)].

●Insert the needle slightly to one side of the midline at 90 degrees to the surface of the bone, as bone marrow tends to be less cellular at the midline ([figure 3](https://www-uptodate-com.ermg.femh.org.tw/contents/image?imageKey=HEME%2F53887&topicKey=HEME%2F4436&search=bone+marrow+Aspiration&rank=1%7E150&source=see_link)).

●The remainder of the sternal aspiration technique is similar to that used for the iliac crest. As noted above, a biopsy at this site is **contraindicated.**

**Tibial aspiration** — Tibial aspiration should be undertaken only in children younger than 12 to 18 months old [[14](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/14)].

●The site of aspiration should be in the upper third of the bone and slightly medial to the anterior crest, from the flat triangular area at the proximal end of the medial surface of the tibia, just below the tibial tubercle [[41](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/41)].

●Angle the needle posterolaterally. Once the needle is secured into the bone, aspiration should be attempted, since the "give" typically felt on aspiration of marrow from the iliac crest is characteristically absent at this site.

●Remove the stylet. Attach a 10 mL syringe and pull back the barrel with some force in order to aspirate sufficient material from the marrow cavity [[14](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/14)].

**Surgical biopsy** — Bone marrow examination may be obtained by an incisional biopsy at a number of different bony sites. An appropriate site is usually determined by prior examination of the patient or by the appropriate radiologic method (eg, CT scan, MRI). As an example, when investigating a patient with possible metastatic cancer or multiple myeloma, it is important to choose an area where there is clinical or radiologic evidence for potential bone marrow invasion [[3](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/3)]. Such procedures may be performed under CT guidance, as required. Bone marrow may also be obtained at the time of a related surgical procedure (eg, resection of a deep lymph node, splenectomy).

**PREPARATION OF SAMPLES**Slides of the aspirated marrow may be prepared at the bedside, or the aspirated material may be anticoagulated and smeared at a later time. Depending on the clinical scenario, up to nine bone marrow direct smears may be prepared.

When performed at the bedside, slides should be prepared rapidly to avoid clotting. Adequacy of the specimen is determined by the presence of "spicules," which appear as fatty droplets, granules, or small chunks of bone, which allow assessment of marrow cellularity. Spicules tend to concentrate at the feathered edge when a smear of the bone marrow is made.

**Materials** — The necessary materials for preparation of aspirate smears include:

●Glass slides and coverslips; both should be clean and free of dirt, grease, oil, or fingerprints

●Sample collection tube(s) with EDTA (liquid EDTA for best morphology)

●Heparinized tubes with culture medium for special studies

●Pusher device for making slides (forceps with hemacytometer cover glass or second slide) (See ['Wedge technique'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H25) below and ['Particle crush technique'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H26) below and ['Coverslip preparations'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H27) below.)

●Petri dish and Pasteur pipette (for coverslip preparations)

**Aspirate** — Place the glass slides in a convenient location before the procedure to allow quick and easy access. Place approximately 0.5 mL of marrow aspirate on one glass slide; if only one or two aspirate samples are to be prepared, the remainder may be added to an EDTA-anticoagulated sample collection tube, mixing well. This should be done immediately to prevent clotting of the specimen. Preparations are then made using one or more of the following three techniques:

**Wedge technique** — A few "particles" (spicules) are placed at the end of one slide and spread evenly down the length using a second glass slide [[2](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/2)]. The second slide should be angled at 30 degrees to the base slide; the drop should be pushed using a rapid, even motion, ending in a particle (spicule)-rich feathered edge [[3,43](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/3,43)].

**Particle crush technique** — This technique yields superior samples than does the wedge technique, but also requires more experience. With this technique, hematopoietic cells are more concentrated and mast cells are more easily evaluated.

As in the wedge technique, a small drop of aspirated marrow is placed at the end of a glass slide. A second glass slide is held parallel and directly over the drop of the aspirate. The second slide is then pressed against the drop of aspirate and pulled across the full length of the first slide to crush open and spread the marrow particles [[3,43](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/3,43)].

**Coverslip preparations** — This type of preparation is considered the most complex of the three types, but yields superior morphology when compared with the wedge or particle crush methods:

●1 to 2 mL of aspirate from the first draw is placed into a petri dish; the dish is then tilted at a slight angle to drain off the blood, making the marrow particles (spicules) more visible.

●One or two particles are then aspirated into a Pasteur pipette and placed on a 22 x 22 mm cover slip.

●A second cover slip is placed diagonally over the first; slight pressure is applied, crushing the particles gently.

●The two cover slips are pulled apart to produce smears. They are then placed into another clean, labeled Petri dish to await staining [[3,43](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/3,43)].

**Particle "clot" section** — This type of specimen is composed of histologic sections of aspirated material.

●The simplest preparation requires drawing a small amount of aspirated material into a plain syringe and allowing it to clot spontaneously; a small amount of thrombin solution may be added to expedite this procedure.

●Another type of preparation, which allows better visualization of the aspirate particles, requires placing a small amount of aspirate into a collection tube containing EDTA. In the laboratory, the anticoagulated material is poured into a bag, where particles are trapped and excess blood is allowed to filter through. The particles are fixed and submitted for processing, sectioning, and staining. The filtered blood is concentrated into four layers by centrifugation; each layer may then be prepared into individual smears [[3,43](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/3,43)].

**The dry tap** — A "dry tap" is defined by a situation in which no bone marrow sample is obtainable by aspiration (ie, there are no identifiable bone spicules in the specimen) despite easily obtained marrow blood. Faulty technique may be the cause, in that the tip of the aspirating needle may not have penetrated into the marrow cavity.

More often, a dry tap is due to alterations within the marrow associated with myeloproliferative or leukemic disorders. Such marrow changes usually involve an element of fibrosis, metastatic tumor infiltration, or granuloma formation [[5](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/5)]. In such cases, bone marrow biopsy should always be performed. Touch preparations of the biopsy can be made which will often provide sufficient cellular material for diagnostic evaluation [[44](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/44)]. (See ["Evaluation of bone marrow aspirate smears", section on 'The dry tap'](https://www-uptodate-com.ermg.femh.org.tw/contents/evaluation-of-bone-marrow-aspirate-smears?sectionName=The+dry+tap&search=bone+marrow+Aspiration&topicRef=4436&anchor=H5&source=see_link#H5).)

There have been rare reports of unexplained iliac crest bone marrow hypoplasia, not explained by sampling issues or by previous trauma or radiation to the site [[45](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/45)].

**Biopsy imprint ("touch") preparation** — If the aspirated specimen is inadequate (devoid of particles) or unobtainable (dry tap), a touch preparation may be prepared from the biopsy core. Cells on the surface of the biopsy core stick to slides and are stained for morphologic, cytochemical, or immunoperoxidase evaluation.

This technique requires placing a fresh core biopsy specimen onto a clean microscope slide. A second slide is then pressed against the core specimen and rolled slightly from side to side. Two or three slides with several imprints on each slide should be prepared in this manner [[3,43](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/3,43)]. The remaining biopsy specimen can be processed normally.

**Biopsy specimen** — The biopsy specimen is placed in fixative (commonly B5-mercuric chloride, [sodium acetate](https://www-uptodate-com.ermg.femh.org.tw/contents/sodium-acetate-drug-information?search=bone+marrow+Aspiration&topicRef=4436&source=see_link), and formalin) for decalcification and tissue section preparation. If specialized testing such as immunohistochemistry or molecular studies may be required, it is useful to discuss this in advance with the pathologist in case it affects the choice of fixative. As an example, B5-based fixatives cannot be used for DNA testing [[46](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/46)].

**POST-PROCEDURE INSTRUCTIONS**Following the procedure, the patient should lie in a supine position, so as to apply body weight to the biopsy site, for at least 10 to 15 minutes. The site should then be inspected to ensure that there is no further bleeding. The patient should be advised that the procedure site may be slightly tender for several days. The following additional routine instructions should be given:

●For pain control, a dose of [acetaminophen](https://www-uptodate-com.ermg.femh.org.tw/contents/acetaminophen-paracetamol-drug-information?search=bone+marrow+Aspiration&topicRef=4436&source=see_link) 650 mg orally is usually adequate. If necessary, the patient may be instructed to continue acetaminophen 650 mg every four to six hours as necessary for the subsequent 24- to 48-hour period.

●The patient should be directed to contact the physician or clinic if swelling, marked tenderness, increased pain, and/or further bleeding is observed [[43](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/43)].

●The patient should avoid overexertion (eg, heavy activity or exercise) for at least 24 hours, to avoid potential pain or bleeding at the site of the procedure. The area of the aspiration/biopsy should be kept dry, using a small dressing or bandage, during this time to minimize the chance of infection or bleeding.

If the patient continues to bleed from the aspirate/biopsy site after an initial observation period of 10 to 15 minutes, it may be prudent to reapply pressure to the site and have the patient lie supine for at least one hour. If bleeding continues after this additional time of observation, it may be necessary to transfuse platelets if the patient is severely thrombocytopenic or if platelet function is suspected to be compromised.

**COMPLICATIONS**Complications following bone marrow biopsy are rare. In a survey of members of the British Society of Haematology reported in 2003, there were 26 adverse events, including one fatality, out of an estimated total of 55,000 biopsy procedures (0.05 percent) [[47](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/47)]. A follow-up survey of this group, reported in 2006 involving 20,323 procedures, resulted in the reporting of 15 adverse events (0.07 percent) [[48](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/48)].

Risk factors for an adverse event included diagnosis of a myeloproliferative disorder, treatment with [aspirin](https://www-uptodate-com.ermg.femh.org.tw/contents/aspirin-drug-information?search=bone+marrow+Aspiration&topicRef=4436&source=see_link) or [warfarin](https://www-uptodate-com.ermg.femh.org.tw/contents/warfarin-drug-information?search=bone+marrow+Aspiration&topicRef=4436&source=see_link), obesity, or disseminated intravascular coagulation. In general, however, when complications do occur, they tend to be minor, mainly consisting of bleeding at the biopsy/aspiration site or infection ([table 3](https://www-uptodate-com.ermg.femh.org.tw/contents/image?imageKey=HEME%2F58801&topicKey=HEME%2F4436&search=bone+marrow+Aspiration&rank=1%7E150&source=see_link)).

**Bleeding** — Hemorrhage from bone marrow aspiration can occur at any site, is more likely in the individual with thrombocytopenia and/or abnormal platelet function, and is associated most commonly with the myeloproliferative disorders [[47-50](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/47-50)]. Of interest, the risk of hemorrhage has not been found to be associated with operator experience [[48](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/48)].

In most cases, bleeding is controlled by manual application of pressure to the site. Pressure dressings should be applied to the site following the procedure in patients with thrombocytopenia. If bleeding continues, platelet transfusions may have to be given if the patient is severely thrombocytopenic, or if platelet function is compromised.

There have been rare reports of retroperitoneal hemorrhage [[14,51,52](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/14,51,52)], gluteal artery laceration or pseudoaneurysm with gluteal compartment syndrome [[48,53](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/48,53)], and internal iliac artery pseudoaneurysm [[52](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/52)]. These are presumed due to penetration of the needle through the inner cortex of the iliac bone. In a CT-based cadaver study, these complications, as well as penetration of the sacroiliac joint, appeared less likely to occur when the needle inserted into the posterior superior iliac spine was pointed in the direction of the ipsilateral anterior superior iliac spine, rather than when it was pointed in a perpendicular direction [[40](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/40)]. (See ['Posterior iliac crest'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H17) above.)

**Infection** — Infections are usually minor, requiring only topical medications. More serious infections may occur in immunocompromised patients. There is a potential risk of contracting infections from a patient, and some recommend double-gloving. However, universal precautions should be applied in all cases, and the operator should always take care to avoid needle penetration of the skin.

**Tumor seeding** — There have been rare case reports of tumor seeding from the bone marrow into the needle track (eg, into muscle, subcutaneous tissue, skin) following bone marrow biopsy, in patients with small cell lung carcinoma, multiple myeloma, and lymphoma [[54-56](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/54-56)].

**Needle breakage** — Rarely, a bone marrow needle may break. If this occurs, an attempt to extract the distal segment with a hemostat should be made. If this maneuver is unsuccessful, a surgeon should be consulted.

**Local radiologic changes** — There may be abnormal radiologic studies of the pelvis post-biopsy, including lytic lesions surrounded by a sclerotic border [[57](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/57)], exostoses [[58,59](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/58,59)], increased bone-seeking isotope uptake [[60](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/60)], or false-positive PET scans in the region of the biopsy procedure [[61](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/61)].

**Other** — Seldom, patients may experience persistent discomfort at the site of biopsy [[48](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/48)]. Exceedingly rare complications have included transient neuropathy with gluteal compartment syndrome secondary to post-biopsy bleeding [[62](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/62)], fracture due to underlying osteoporosis [[48](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/48)], and/or osteomyelitis [[2](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/2)].

**Sternal aspiration** — Complications of sternal aspiration are rare, but merit special consideration due to their potential seriousness. The sternum is only one centimeter thick in the adult, which may predispose to through-and-through penetration of the sternum with potentially fatal cardiovascular complications, pericardial tamponade, pneumothorax, pulmonary emboli, infection, and bone erosion, thinning, or sternal fracture [[63](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique/abstract/63)]. Sternal aspiration should not be undertaken in young children due to the risk of perforating the sternal plate. For the same reasons, marrow biopsy at sternal sites is contraindicated.

**SUMMARY AND RECOMMENDATIONS**

**Indications and contraindications**

The following medical settings constitute the major indications for bone marrow aspiration and/or biopsy. (See ['Indications'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H3) above.)

●Evaluation of unexplained anemia, leukopenia, thrombocytopenia, or pancytopenia

●Diagnosis and staging of lymphoma or solid tumors

●Evaluation of elevated peripheral blood counts (eg, polycythemia, thrombocytosis, leukocytosis)

●Diagnosis and evaluation of plasma cell disorders and leukemias

●Evaluation of iron metabolism and iron stores

●Evaluation of suspected deposition and storage diseases (eg, amyloidosis, Gaucher disease)

●Evaluation of fever of undetermined origin, suspected mycobacterial, fungal, or parasitic infections, or granulomatous diseases

●Unexplained splenomegaly

●Evaluation of suspected chromosomal disorders in neonates

●Confirmation that the bone marrow is normal in a potential allogeneic hematopoietic cell donor

Bone marrow aspiration and/or biopsy is contraindicated patients with severe hemophilia, severe disseminated intravascular coagulation, or other related severe bleeding disorders. Thrombocytopenia, regardless of severity, is **not** a contraindication. (See ['Contraindications'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H4)above.)

**Aspiration/biopsy sites** — The following anatomical sites can be used for bone marrow aspiration. (See ['Choice of aspiration or biopsy site'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H6) above.)

●Posterior (preferred) or anterior iliac crest. The iliac crest is the only site at which both aspiration and biopsy may be safely performed in the adult.

●Sternum. Marrow may be aspirated from the sternum by experienced clinicians; biopsy at this site is **contraindicated.**

●Other sites include the tibia, femur, vertebral bodies, ribs. Surgical consultation is advisable when such sites are considered, especially for open biopsies

**Complications of the procedure** — Complications of bone marrow aspiration/biopsy are uncommon (estimated at 0.05 to 0.07 percent in two series). (See ['Complications'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H31) above.)

●The most commonly encountered complications include pain, discomfort, and/or bleeding at the site of the procedure.

●Complications of sternal aspiration can be serious and are discussed in detail above. (See ['Sternal aspiration'](https://www-uptodate-com.ermg.femh.org.tw/contents/bone-marrow-aspiration-and-biopsy-indications-and-technique?search=bone%20marrow%20Aspiration&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1#H1277329) above.)

**ACKNOWLEDGMENT**The editors of UpToDate acknowledge the contributions of Stanley L Schrier, MD as Section Editor on this topic, his tenure as the founding Editor-in-Chief for UpToDate in Hematology, and his dedicated and longstanding involvement with the UpToDate program.

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