STERNAL MARROW BIOPSY

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Sternal puncture has become established as a useful diagnostic aid since its introduction by Arinkin (1929) just 20 years ago. The bone marrow in the sternum remains haemopoietically active until late in life and during regeneration shows increased activity more readily than many other bones.

To perform sternal puncture an area of skin at the level of the second or third intercostal space, just to one side of the midline, is anaesthetized and through it the periosteum is infiltrated. The

FIG. 1.—Sternal puncture needle. Klima's pattern, modified by Britton.

puncture needle (Fig. 1) is pushed through the skin and its guard fixed 0.5 cm. above the skin level. The cortex of the sternum is pierced slightly obliquely by gentle rotatory movements, while the patient holds his breath in inspiration for a few seconds. A sudden give is felt when the spongy bone marrow is reached. A well-fitting 5 ml. syringe which has been rinsed in saline is attached to the

needle and about 0.3 ml. of fluid is aspirated. The patient experiences a short, sharp pain when suction is made. The marrow material is placed in a watch glass and smears are made at once and dried by waving them rapidly. If desired the total nucleated cell content is estimated by the method used for counting leucocytes. The remaining specimen is allowed to clot, fixed in Helly's fluid, sectioned and stained like a histological preparation. Macroscopic examination of the material should not be neglected. An increase of fat globules may indicate aplastic or hypoplastic conditions, and an increase of little greyish marrow fragments occurs in hyperplasia. The smears are stained with Leishman's or other similar stains and examined microscopically. Megakaryocytes are usually easily identified with the low power lens, and confirm that the material obtained is in fact bone marrow. The marrow smears are carefully studied with the immersion lens and at least 500 cells are counted and classified. The normal figures for sternal marrow counts (Whitby and Britton, 1941) are shown in Table 1.

TABLE 1

Normal Myelogram

Myeloid cells:

Neutrophil polymorphs	..	..	20-50	per cent
Eosinophil polymorphs	..	..	0-4	"
Neutrophil metamyelocytes	..	..	2.5-12	"
Eosinophil metamyelocytes	..	..	0-2.5	"
Neutrophil myelocytes	..	..	2-8	"
Eosinophil myelocytes	..	..	0-1	"
Basophils	..	..	0-1	"
Promyelocytes	..	..	0.5-5	"
Myeloblasts	..	..	0-2.5	"

Erythroid cells:

Late (orthochromatic) normoblasts	7-19	"
Early (basophilic) and intermediate (polychromatic) normoblasts	4-15	"
Proerythroblasts	0-4	"
Haemocytoblasts	0-1	"

Other cells:

Lymphocytes	5-20	"
Monocytes	0-5	"
Plasma cells	0-1	"
Megakaryocytes	0.2-1	"

Myeloid-erythroid ratio 8: 1-2: 1

TABLE 2

ORIGIN OF BLOOD CELLS

The development of cells is shown diagrammatically in Table 2, but it should be remembered that megaloblasts are not normally seen in the marrow, and megalocytes do not normally occur in the blood. Their morphology can be studied in the more detailed books, such as the monograph by Leitner (1949). Mitotic figures can be readily studied in sternal marrow preparations and in many instances provide useful information in assessing disorders of the haemopoietic organs, their activity, severity and prognosis.

In the untreated case of pernicious anaemia the marrow is characterized by megaloblastic hyperplasia, but the myeloid cells and the megakaryocytes also show certain changes, such as large cell forms. Treatment with liver should not be commenced until a definite diagnosis is reached. Following the administration of liver in adequate amounts the megaloblastic marrow becomes transformed into normoblastic marrow, often as rapidly as in 6 to 12 hours. Sprue, pernicious anaemia of pregnancy, tropical megalocytic anaemia and achrestic anaemia show marrow pictures similar to classical pernicious anaemia. Megaloblasts such as described by Turnbull (1936) are only seen in pernicious and allied anaemias (Figs. 2 and 3).

Idiopathic hypochromic anaemia, the haemorrhagic anaemias and most secondary anaemias show normoblastic hyperplasia of the erythropoietic marrow portion. Certain other symptomatic anaemias, such as in nephritis, severe infections, benzol poisoning and in malignant disease, may show hypoplasia and in such cases the prognosis is less favourable, but the normoblasts may increase in response to treatment. In aplastic anaemia, myelosclerosis, and similar conditions the total number of marrow cells is much reduced, and therefore the percentage of lymphocytes may be increased, though their absolute figure is not altered.

In the haemolytic anaemias, such as haemolytic icterus, Cooley's anaemia and in toxic haemolytic states, the increase of erythroblasts is particularly marked and extreme marrow hyperplasia may cause skeletal changes. Polycythaemia rubra vera affects all three marrow systems (red, white and megakaryocytic) by hyperplasia, but in erythrocytosis only the normoblasts are increased. Erythraemic myelosis (di Guglielmo's disease) is characterized by enormous pathological erythroblastic hyperplasia and suppression of the myeloid and megakaryocytic series of cells.

In chronic myeloid leukaemia, sternal marrow

FIG. 2.—Megloblasts, normoblasts and giant myelocytes. The early megaloblast near the polymorph shows the typical fine chromatin structure. From an untreated case of pernicious anaemia (Leishman, x 1,000).

FIG. 3.—An early megaloblast with pseudopodia of the cytoplasm and abnormal mitosis of the nucleus. From a case of pernicious anaemia in relapse (Leishman, x 600).

FIG. 4.—Neutrophil polymorphs, myelocytes, promyelocytes and a megakaryocyte. From a case of chronic myeloid leukaemia (Leishman, x 1,000).

FIG. 5.—Myeloblasts, one of them in mitosis, with little cytoplasm and nucleoli in the nucleus. From a case of acute myeloid leukaemia and chloroma (Leishman, x 1,000).

FIG. 6.—Large primitive plasma cells with basophilic cytoplasm, some with cartwheel pattern of the nucleus. From a case of multiple myelomatosis (Leishman, x 400).

FIG. 7.—Megakaryocytes in various stages of maturation, those with pleomorphic nuclei forming platelets. From a case of idiopathic thrombocytopenic purpura (Leishman, x 500).

FIG. 8.—Sternal trephine. Infiltration of bone marrow by lymphoid cells while megakaryocytes remain. From a case of lymphatic leukaemia (Haematoxylin and eosin, x 235).

biopsy produces a picture similar to that found in the peripheral blood, but it is in the cases without leucocytosis that sternal puncture is of diagnostic importance (Figs. 4 and 5). Lymphatic leukaemia does not affect the bone marrow primarily and therefore in early cases a characteristic myelogram cannot always be expected. Once the bone marrow is infiltrated (Fig. 6) the number of lymphocytes and immature lymphoid cells in the marrow is much increased. In acute leukaemia the distinction between myeloid and lymphatic leukaemia is often impossible, even with the help of marrow biopsy; some cases show myeloblasts with lobed nuclei ('paramyeloblasts' of Naegeli's terminology) which simulate monocytes. In the marrow as well as in the blood these active cells indicate a rapidly progressive disease and herald a fatal prognosis. Multiple myelomatosis in the majority of cases is easily diagnosed by sternal puncture. The plasma cells or their precursors are unusually numerous, sometimes almost to the exclusion of other cells (Fig. 6).

Sternal marrow biopsy is particularly valuable in the accurate diagnosis and assessment of prognosis in cases of agranulocytosis, aplastic anaemia and other marrow aplasias. In the majority of cases there is maturation arrest with a normal number of early cells and a decrease of polymorphs and late normoblasts only. In such cases recovery may be expected, but when there is aplasia or severe hypoplasia of the myeloid or erythroid series the prognosis must be guarded. Sometimes the true nature of the pathological process can only be revealed by repeated sternal punctures or a sternal trephine.

Some case of glandular fever show a peripheral blood picture which simulates leukaemia. The absence of the atypical cells from the marrow will help when the differential diagnosis is difficult and will exclude leukaemia.

In deciding whether or not a case of thrombocytopenic purpura will benefit from splenectomy sternal puncture is particularly valuable. When the megakaryocytes and their precursors are scanty or absent, splenectomy will rarely be followed by a

cure, but when the non-platelet-forming promegakaryocytes are abundant, splenectomy frequently results in a removal of the inhibition of maturation (Fig. 7).

Occasionally malignant disease may be diagnosed by the finding of clusters of cells in the marrow, but these cases are, of course, those with skeletal metastases and such advanced stages may be diagnosed or suspected by the appearance of immature red and white cells in the peripheral blood, i.e. leuco-erythroblastic anaemia. In Hodgkin's disease, late cases may show the typical mirror-image giant cells, usually associated with the names of Dorothy Reed and Sternberg. For the detection of malarial parasites, leishmania or microfilariae sternal puncture is better than splenic puncture because it is much safer.

Sternal puncture has been used for blood transfusion, infusions and the injection of therapeutic preparations, but such a procedure is difficult and often hazardous. Intramedullary infusions can only be given very slowly and they are therefore useless in an emergency.

A thorough general search of marrow smears, the differential count of marrow cells in several stained preparations and the interpretation of the results obtained is a laborious process and usually occupies even a skilled worker for at least two hours. It rewards him with a thorough training in cytology and a variety of sometimes very beautiful morphological pictures, especially when mitotic figures are studied.

Fig. 6 is included by courtesy of the Editor of *St. Mary's Hospital Gazette*. The other photomicrographs are by W. Pereira.

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