HbE and a β thalassemia gene can have β thalassemia intermedia or β thalassemia major, depending on the severity of the coinherited thalassemic gene.

The β^E allele contains a single base change in codon 26 that causes the amino acid substitution. This mutation also activates a cryptic RNA splice site, generating a structurally abnormal globin mRNA that cannot be translated, from about 50% of the initial pre-mRNA molecules. The remaining 40–50% are normally spliced and generate functional mRNA that is translated into β^E-globin because the mature mRNA carries the base change that alters codon 26.

Genetic counseling of the persons at risk for HbE should focus especially on the interaction of HbE with β thalassemia, because HbE homozygosity is a condition associated with mildly asymptomatic microcytosis, hypochromia, and hemoglobin levels rarely <100 g/L (<10 g/dL).

HEREDITARY PERSISTENCE OF FETAL HEMOGLOBIN

HPFH is characterized by continued synthesis of high levels of HbF in adult life. No deleterious effects are apparent, even when all of the hemoglobin produced is HbF. These rare patients demonstrate convincingly that prevention or reversal of the fetal to adult hemoglobin switch would provide effective therapy for sickle cell anemia and β thalassemia.

ACQUIRED HEMOGLOBINOPATHIES

The two most important acquired hemoglobinopathies are carbon monoxide poisoning and methemoglobinemia (see above). Carbon monoxide has a higher affinity for hemoglobin than does oxygen; it can replace oxygen and diminish O_2 delivery. Chronic elevation of carboxyhemoglobin levels to 10 or 15%, as occurs in smokers, can lead to secondary polycythemia. Carboxyhemoglobin is cherry red in color and masks the development of cyanosis usually associated with poor O_2 delivery to tissues.

Abnormalities of hemoglobin biosynthesis have also been described in blood dyscrasias. In some patients with myelodysplasia, erythroleukemia, or myeloproliferative disorders, elevated HbF or a mild form of HbH disease may also be seen. The abnormalities are not severe enough to alter the course of the underlying disease.

TREATMENT TRANSFUSIONAL HEMOSIDEROSIS

Chronic blood transfusion can lead to bloodborne infection, alloimmunization, febrile reactions, and lethal iron overload **(Chap. 138e)**. A unit of packed RBCs contains 250–300 mg iron (1 mg/mL). The iron assimilated by a single transfusion of 2 units of packed RBCs is thus equal to a 1- to 2-year oral intake of iron. Iron accumulates in chronically transfused patients because no mechanisms exist for increasing iron excretion: an expanded erythron causes especially rapid development of iron overload because accelerated erythropoiesis promotes excessive absorption of dietary iron. Vitamin C should not be supplemented because it generates free radicals in iron excess states.

Patients who receive >100 units of packed RBCs usually develop hemosiderosis. The ferritin level rises, followed by early endocrine dysfunction (glucose intolerance and delayed puberty), cirrhosis, and cardiomyopathy. Liver biopsy shows both parenchymal and reticuloendothelial iron. The superconducting quantum-interference device (SQUID) is accurate at measuring hepatic iron but not widely available. Cardiac toxicity is often insidious. Early development of pericarditis is followed by dysrhythmia and pump failure. The onset of heart failure is ominous, often presaging death within a year **(Chap. 428)**.

The decision to start long-term transfusion support should also prompt one to institute therapy with iron-chelating agents. Deferoxamine (Desferal) is for parenteral use. Its iron-binding kinetics require chronic slow infusion via a metering pump. The constant presence of the drug improves the efficiency of chelation and protects tissues from occasional releases of the most toxic fraction of iron—low-molecular-weight iron—which may not be sequestered by protective proteins.

Deferoxamine is relatively nontoxic. Occasional cataracts, deafness, and local skin reactions, including urticaria, occur. Skin reactions can usually be managed with antihistamines. Negative iron balance can be achieved, even in the face of a high transfusion requirement, but this alone does not prevent long-term morbidity and mortality in chronically transfused patients. Irreversible end-organ deterioration develops at relatively modest levels of iron overload, even if symptoms do not appear for many years thereafter. To enjoy a significant survival advantage, chelation must begin before 5–8 years of age in β thalassemia major.

Deferasirox is an oral iron-chelating agent. Single daily doses of 20–30 mg/kg deferasirox produced reductions in liver iron concentration comparable to deferoxamine in long-term transfused adult and pediatric patients. Deferasirox produces some elevations in liver enzymes and slight but persistent increases in serum creatinine, without apparent clinical consequence. Other toxicities are similar to those of deferoxamine. Its toxicity profile is acceptable, although long-term effects are still being evaluated.

EXPERIMENTAL THERAPIES

BONE MARROW TRANSPLANTATION, GENE THERAPY, AND MANIPULATION OF HbF

Bone marrow transplantation provides stem cells able to express normal hemoglobin; it has been used in a large number of patients with β thalassemia and a smaller number of patients with sickle cell anemia. Early in the course of disease, before end-organ damage occurs, transplantation is curative in 80–90% of patients. In highly experienced centers, the treatment-related mortality is <10%. Because survival into adult life is possible with conventional therapy, the decision to transplant is best made in consultation with specialized centers.

Gene therapy of thalassemia and sickle cell disease has proved to be an elusive goal, but experimental advances are raising expectations.

Reestablishing high levels of fetal hemoglobin synthesis should ameliorate the symptoms of β-chain hemoglobinopathies. Cytotoxic agents such as hydroxyurea and cytarabine promote high levels of HbF synthesis, probably by stimulating proliferation of the primitive HbF-producing progenitor cell population (i.e., F cell progenitors). Unfortunately, this regimen has not yet been effective in β thalassemia. Butyrates stimulate HbF production, but only transiently. Pulsed or intermittent administration has been found to sustain HbF induction in the majority of patients with sickle cell disease. It is unclear whether butyrates will have similar activity in patients with β thalassemia.

APLASTIC AND HYPOPLASTIC CRISIS IN PATIENTS WITH HEMOGLOBINOPATHIES

Patients with hemolytic anemias sometimes exhibit an alarming decline in hematocrit during and immediately after acute illnesses. Bone marrow suppression occurs in almost everyone during acute and chronic inflammatory illnesses. In patients with short RBC life spans, suppression can affect RBC counts more dramatically. These hypoplastic crises are usually transient and self-correcting before intervention is required.

Aplastic crisis refers to a profound cessation of erythroid activity in patients with chronic hemolytic anemias. It is associated with a rapidly falling hematocrit. Episodes are usually self-limited. Aplastic crises are caused by infection with a particular strain of parvovirus, B19A. Children infected with this virus usually develop permanent immunity. Aplastic crises do not often recur and are rarely seen in adults. Management requires close monitoring of the hematocrit and reticulocyte count. If anemia becomes symptomatic, transfusion support is indicated. Most crises resolve spontaneously within 1–2 weeks.