sources of energy, principally fat. Consequently, fats break down into fatty acids, and glycerol in the fat cells is converted by the liver to ketone bodies (β-hydroxybutyric acid, acetoacetic acid, acetone). Any excess is eliminated in the urine (**ketonuria**) or the lungs (**acetone breath**). The ketone bodies in the blood (ketonemia) are strong acids that lower serum pH, producing **ketoacidosis**.

Ketones are organic acids that readily produce excessive quantities of free hydrogen ions, causing a fall in plasma pH. Then chemical buffers in the plasma, principally bicarbonate, combine with the hydrogen ions to form carbonic acid, which readily dissociates into water and carbon dioxide. The respiratory system attempts to eliminate the excess carbon dioxide by increased depth and rate (Kussmaul respirations, or the hyperventilation characteristic of metabolic acidosis). The ketones are buffered by sodium and potassium in the plasma. The kidneys attempt to compensate for the increased pH by increasing tubular secretion of hydrogen and ammonium ions in exchange for fixed base, thus depleting the base buffer concentration.

With cellular death, potassium is released from the cells (intracellular fluid) into the bloodstream (extracellular fluid) and excreted by the kidneys, where the loss is accelerated by osmotic diuresis. The total body potassium is then decreased even though the serum potassium level may be elevated as a result of the decreased fluid volume in which it circulates. Alteration in serum and tissue potassium can lead to cardiac arrest.

If these conditions are not reversed by insulin therapy in combination with correction of the fluid deficiency and electrolyte imbalance, progressive deterioration occurs, with dehydration, electrolyte imbalance, acidosis, coma, and death. **Diabetic ketoacidosis (DKA)** should be diagnosed promptly in a seriously ill patient and therapy instituted in an intensive care unit.

Long-Term Complications

Long-term complications of diabetes involve both the microvasculature and the macrovasculature. The principal microvascular complications are **nephropathy**, **retinopathy**, and **neuropathy**. Microvascular disease develops during the first 30 years of diabetes, beginning in the first 10 to 15 years after puberty, with renal involvement evidenced by proteinuria and clinically