

situations or when patients are unconscious or unable to accept oral medication, and in cases when drugs are destroyed, inactivated or poorly absorbed following oral administration. In general, blood levels attained are more predictable than those achieved by oral dosage forms.

Injectable preparations are usually sterile solutions or suspensions of drugs in water or other suitable physiologically acceptable vehicles. As referred to previously, drugs in solution are rapidly absorbed and thus suspension injections are slower acting than solution injections. In addition, since body fluids are aqueous, by using drugs suspended in oily vehicles, a preparation exhibiting slower absorption characteristics can be formulated to give a depot preparation, providing a reservoir of drug which is slowly released into the systemic circulation. Such preparations are administered by intramuscular injection deep into skeletal muscles (e.g. several penicillin-containing injections). Alternatively, depot preparations can be achieved by subcutaneous implants or pellets, which are compacted or moulded discs of drug placed in loose subcutaneous tissue under the outer layers of the skin. Such systems include solid microspheres, biodegradable polymeric microspheres (e.g. polylactide co-glycolic acid homo- and copolymers) containing proteins or peptides (e.g. human growth hormone and leuprolide). More generally, subcutaneous injections are aqueous solutions or suspensions which allow the drug to be placed in the immediate vicinity of blood capillaries. The drug then diffuses into the capillaries. Inclusion of vasoconstrictors or vasodilators in subcutaneous injections will clearly influence blood flow through the capillaries, thereby modifying the capacity for absorption. This principle is often used in the administration of local anaesthetics with the vasoconstrictor adrenaline, which delays drug absorption. Conversely, improved drug absorption can result when vasodilators are included. Intravenous administration involves injection of sterile aqueous solutions directly into a vein at an appropriate rate. Volumes delivered can range from a few millilitres, as in emergency treatment or for hypnotics, up to litre quantities, as in replacement fluid treatment or nutrient feeding.

Given the generally negative patient acceptance of this important route of drug delivery, primarily associated with pain and inconvenience, recent developments to help with self-injection by patients have focused on 'needle-free' injection systems and devices which propel drug in aqueous solution or

powder form at high velocity directly through the external layers of the skin.

Topical route

Drugs are applied topically, that is to the skin, mainly for local action. Whilst this route can also be used for systemic drug delivery, percutaneous absorption is often poor and erratic, although several transdermal patches delivering drug for systemic distribution (e.g. fentanyl patches for severe pain management and nicotine patches for cessation of smoking) are available. Drugs applied to the skin for local effect include antiseptics, antifungals and anti-inflammatory agents, as well as skin emollients for protective effects.

Pharmaceutical topical formulations – ointments, creams and pastes – are composed of drug in a suitable semi-solid base which is either hydrophobic or hydrophilic in character. The bases play an important role in determining the drug release character from the formulation. Ointments are hydrophobic, oleaginous-based dosage forms, whereas creams are semi-solid emulsions. Pastes contain more solids than ointments and thus are stiffer in consistency. For topical application in liquid form other than solution, lotions, suspensions of solids in aqueous solution or emulsions are used.

Application of drugs to other topical surfaces such as the eye, ear and nose is common and ointments, creams, suspensions and solutions are utilized. Ophthalmic preparations are required, amongst other features, to be sterile. Nasal dosage forms include solutions or suspensions delivered by drops or fine aerosol from a spray. Ear formulations in general are viscous to prolong contact with affected areas.

Respiratory route

The lungs provide an excellent surface for absorption when the drug is delivered in gaseous, aerosol mist or ultrafine solid particle form. For drug particles presented to the lungs as an aerosol, particle size largely determines the extent to which they penetrate the alveolar region, the zone of rapid absorption. Drug particles that are in the region 0.5–1 μm diameter reach the alveolar sacs. Particles smaller than this range are either exhaled or, if larger, deposited upon larger bronchial airways. This delivery route is particularly useful for the direct treatment of asthmatic problems, using both powder aerosols (e.g. salmeterol xinafoate) and pressurized metered