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Open or closed incubators

Definitions

According to the *Oxford English Dictionary*, to 'incubate' means 'to sit upon the eggs in order to hatch them'. In this wide sense a neonatal unit might be viewed as an incubator for preterm infants. The question 'to whom is it open and to whom is it closed?' is important, though perhaps not what the editors had in mind for this annotation. The relevant *Oxford English Dictionary* definition of 'incubator' is 'an apparatus for rearing children born prematurely'. We might infer from both definitions that a protected, warm, controlled environment is necessary to rear young until they are ready for independence, though neither mentions specifically either temperature or heater.

Why incubate?

All babies have to produce heat as a byproduct of metabolic activities, and if body temperature was our only concern we could maintain this by insulation with clothing and bedding, without strict control of environmental temperature. In our anxiety to give adequate observation and attention to sick, premature infants we may choose to nurse them naked on open surfaces. If body temperature is to be maintained without extra metabolic demand we must provide the infant with the controlled 'personal climate' of a heated incubator. Those who are concerned with improving neonatal care know instinctively that the open surfaces, bright lights, and noise are unnatural, and yet babies survive. Indeed, we take comfort in the improving survival rates. From this it would seem only fair to conclude that current incubating systems satisfactorily perform their basic task, at least for most infants.

Apparatus

Two types of incubator are in common use, differing largely in the way they control heat exchange. In the 'closed' incubator, warm air is blown through a canopy around the baby, with the temperature of the air controlled either directly by the user or indirectly by servocontrol of the baby's skin temperature. In the 'open' incubator, or radiant warmer, the baby is placed on an open surface with a radiant heat element fixed horizontally above, and the heater output is servocontrolled from skin temperature. The inner walls of the closed incubator are usually a few degrees cooler than the warmed air, thus the baby loses most heat by radiation to the walls, with low convective losses. By contrast, convective losses are very high under the radiant warmer because the surrounding air is virtually at room temperature. Radiant heat is gained by skin surfaces that face the heat element and lost by other surfaces, giving a net radiant gain.

Preterm infant

For infants born at 28 weeks' gestation or more, both systems are undoubtedly capable of providing adequate and equivalent *physical* environments, in terms of environmental temperature and net heat exchange. However, the 'personal climates' are clearly different, and they are not judged as equivalent by babies. There are many reports of significantly increased insensible water loss under radiant warmers.[1–5] Studies have also shown that small babies have a slightly[4 6] or significantly[5 7] higher rate of metabolic heat production under an open warmer than in a closed incubator. However, babies[7] showed no difference in metabolic rate between a conventional closed incubator and one with a heated canopy.[8] It seems, therefore, that some feature of the open warmer system, but not radiant heat itself, increases metabolism—even though the baby can 'demand' heat through the servocontrol system. Our suggestion is that the pronounced fluctuations of the incident radiation[5] and the spatial asymmetry under the open warmer are uncomfortable. Adults dislike pronounced asymmetry, and we have no reason to assume that babies differ.

We do not know whether the differences in water loss and metabolic rate are clinically (as opposed to statistically) significant, but if we work on the assumption that minimal water loss and energy cost are desirable then the closed incubator performs its primary task better than the open warmer.

Our practice is to nurse premature babies in closed incubators without servocontrol. Whenever possible they have the thermal and social benefit of at least some clothing—bonnets, 'preterm' jumpsuits, dresses, and smocks. Clothing can confuse the operation of a servocontrol system if this has been designed correctly for a naked baby.

Very preterm infant

The above applies to infants with water tight skins.

Infants under 28 weeks' gestation have leaky skins in the first few weeks of life and as a consequence have high evaporative water and heat losses. These are the infants for whom control of the personal climate is most crucial, but their vulnerability makes detailed experimental study impossible.

Neither closed incubator nor open warmer provides an acceptable environment when used in the conventional way. The former fails to keep the infant warm, because 'safety' standards prohibit air temperatures that are sufficiently high. The latter increases the already serious water loss.[5]

Currently, we nurse such infants in a high humidity for the first week or so of life to reduce evaporative water loss and clothe them wherever it is possible with bonnets, smocks, nappies, bootees, etc.

Personal space

Concern about the inadequacy of current incubators has led to modifications, canopies within canopies, high humidity, plastic sheets, and clothing within closed incubators; and shields, plastic sheets, and heated nursing surfaces under open warmers.[9–13] All alter the thermal environment and may introduce their own hazards; most make the system more 'closed' with respect to access to the baby.

The time has come for a radical redesign of incubators, not just 'Do it yourself' modifications, but this has to be thought out in the context of redesigned neonatal units. We must stop the 'personal climate' from dictating the design of the 'personal space'.

The requirements of the ideal 'personal space' for a preterm infant are challenging and conflicting. The surrounding gases should be under sensitive and rapid control with respect to oxygen content, humidity, and temperature, and the temperature of all surrounding surfaces should be controlled. Light and noise levels should be measured, excesses avoided, and possibly background levels cycled. The infants need support but minimal handling, protection but easy access. For some activities (nursing, medical, and social) the space needs to be 'open', for others it should be 'closed'. This may well involve adjustable heated canopies.

The whole should be a great deal more sympathetic to infants, parents, and nursing staff than it is at present. We must use our technical skills to make our neonatal nurseries more effective, but also more homely.

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