Methods

Reducing injection pain in children with diabetes

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Indwelling catheters

The subcutaneous insulin catheter consists of a teflon catheter (cannula) sealed by a silicone membrane in the outer end (Fig. 20). The length of the catheter is 19 mm, the inner lumen of the catheter 0.4 mm and the outer diameter 0.6 mm (24G). The catheter is placed subcutaneously with the help of a metal needle (27G, 0.4 mm) which is removed after insertion. The cannula is fixed to the skin using an enclosed adhesive.

The first design was hand made at Uddevalla Hospital from a plexiglass plug fitted into a 24 G intravenous cannula (Neoflon, Viggo AB, Sweden) in 1985 (Fig. 17). The catheter is now commercially available (Insuflon, originally Viggo AB, Sweden, now Maersk Medical A/S, Denmark). The author has no personal financial interest in this device. Insuflon is used continuously by approximately 100 children and

<table>
<thead>
<tr>
<th>Insertion of needle</th>
<th>Dead space, insulin 100 U/ml</th>
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<tbody>
<tr>
<td>3 mm</td>
<td>0.61 ± 0.05 U</td>
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<tr>
<td>8 mm</td>
<td>0.49 ± 0.04 U</td>
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<tr>
<td>13 mm</td>
<td>0.48 ± 0.03 U</td>
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<tr>
<td>Theoretical dead space</td>
<td>0.75 U</td>
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Table 4) Dead space of the Insuflon indwelling catheter, measured by injecting insulin in vitro.2 The injection was made into a cup of water and the syringe needle was removed while the tip was still in water. The corresponding number of units was calculated from weight on a precision scale, mean of 15 catheters, ± SD.2

Fig 19) In vitro studies (mean of 10 catheters injected in vitro using isotope-labelled solutions) showed that when the catheter is used for two types of insulin 0.1 - 0.2 U of the first injected insulin remains in the catheter.2

Fig 18) The needles in study VIIA (left photo) were of the same length, the base being hidden by a neutral cap. In study VIIIB (right photo) we used a KabiPen® 16 with a retractable cap (PenCover®) that hid the needle (or absence of needle).

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adolescents in Sweden and in total by 700-1000 persons on a worldwide basis. The dead space is dependable upon how deep the injection needle is inserted into the catheter (Table 4). The silicone membrane has been shown to be good for 75 penetrations without leakage, using standard 27G (0.4 mm) needles. Some early pen needles with very thin walls (Insuject®, 27G, Nordisk Gentofte A/S, Denmark) did occasionally punch out a very small piece of the silicone membrane. This did not result in a membrane leakage but sometimes the needle was blocked.

The technique of using indwelling catheters is initially taught to the family by the diabetes team at the clinic. Parents usually learn how to replace them at home after a few times of practice. Most younger children use a local anesthetic cream (EMLA®, Astra, Sweden) when replacing the indwelling devices, especially when they are new to the method.

### Syringes, pen and pump needles

Both syringes and pen injectors had needles of 27G (0.4 mm) at the time of the questionnaire study (II). In study II, teflon catheters (Neoflon®, Viggo-Spectramed, Sweden) of 0.6 mm diameter or 0.4 mm metal needles were used for CSII. See Table 5 for characteristics of used pen needles. The finger-pricking device Autoclix P® (Boehringer-Mannheim, Stockholm, Sweden) was used in studies VI and VII.

### Insulin absorption

An uncollimated gamma-camera (Picker SX300, Picker, USA) was used to measure the disappearance of $^{125}$I-labelled insulin from the injection sites. The sensitivity was found to be about 1400 cpm/kBq and the spatial resolution

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*Fig 20* The Insuflon Cannula (Maersk Medical, Denmark) is an indwelling catheter consisting of a plastic tube with a silicone membrane and a teflon catheter. The insulin is deposited in the subcutaneous tissue. Both pen injectors and syringes can be used for injections.