胰島素泵新手入門
Insulin Pump for Beginners

目錄 Content

胰島素泵和連續式葡萄糖監測裝置
Insulin Pump and Continuous Glucose Monitoring System (CGMS)

胰島素泵 Insulin pump

- 胰島素泵是輸送胰島素的電子裝置。
  An insulin pump is an electronic device that delivers insulin.

- 用家需要設定內置劑量計算系統、輸入血糖讀數和碳水化合物攝入量，來估計胰島素需求量，然後指令胰島素泵輸出適量的胰島素。
  Users need to input a programmed calculation system, blood glucose readings and the amount of carbohydrate to be consumed. The insulin pump will then calculate the amount of bolus insulin to be delivered based on the pre-set programme.

- 通常可與連續式葡萄糖監測裝置互通。
  It usually communicates with CGMS.

胰島素泵組件包括 An insulin pump set includes：
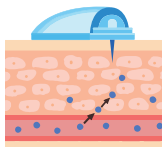
泵裝置：一個包括操作介面和處理系統的小機器
A pump: A small machine that contains user interface and electronic processor

一次性胰島素儲液器及輸液器（通常需要每三天更換一次）
A disposable insulin reservoir and a disposable infusion set
(to be changed every 3 days usually)

連續式葡萄糖監測裝置 Continuous Glucose Monitoring System (CGMS)

- 在皮膚下的感應器監測組織液的葡萄糖濃度
  A device inserted under the skin to measure interstitial glucose level continuously.

- 感應器讀數是來自組織液而非血液，可能與血糖讀數不同
  Sensor glucose may be different from blood glucose because it measures glucose in interstitial fluid.

- 組織液葡萄糖相對血糖變化大約延遲五至十分鐘
  There is a lag time of 5-10 minutes between sensor glucose and blood glucose.

連續式葡萄糖監測裝置可連續取得皮下組織液的葡萄糖讀數，能更有效地取得葡萄糖趨勢。這個監測裝置可獨立使用，亦可配合胰島素泵使用。
A CGMS measures interstitial fluid glucose continuously so there is a better idea on the glucose trend. It can be used as a standalone device or in combination with an Insulin Pump.

甚麼是混合／半閉環系統？
What is a Hybrid/partially-closed loop system?

如今，市場上大多數胰島素劑量計算裝置，會根據感應器葡萄糖值，自動調節基礎胰島素的輸注速率，但用者仍需要輸入進食的碳水化合物量，輸注餐前大劑量胰島素。因此，它仍然是混合／半閉環系統。

Currently, most computer algorithm available on the market can only automatically determine the basal insulin dose based on glucose measurement by CGMS. For the bolus insulin dose, users are still required to enter the carbohydrate portions and give meal bolus. Therefore, it is still a hybrid/partially closed-loop system.

由3個基本部分組成
Consists of 3 components

- **連續葡萄糖監測裝置**
  Continuous Glucose Monitoring System (CGMS)

- **胰島素劑量計算裝置**
  Computer algorithm
  根據感應器葡萄糖值，以電腦系統計算出適當胰島素輸注量，包括基礎和餐後大劑量輸注。
  Automatically calculates the basal and bolus insulin dose based on glucose measurement by CGMS.

- **胰島素泵**
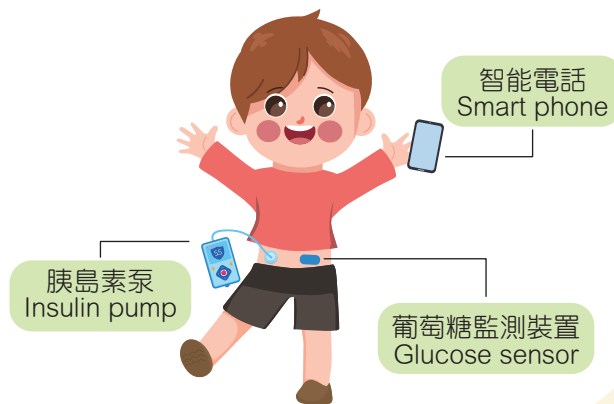 **Insulin pump**
  根據計算指令，進行輸注。
  Delivers insulin.

看看我！我正在使用半閉環系統。
Look at me! I am wearing partially-closed loop system.

智能電話
Smart phone

胰島素泵
Insulin pump

葡萄糖監測裝置
Glucose sensor

透過以上3個部分，人工胰臟可以自動調節劑量並提供胰島素的輸送。

Communication between the CGMS, insulin pump and computer algorithm will create a partially-closed-loop system that can automatically adjust the rate and deliver insulin.

胰島素泵如何輸送胰島素？
How does an Insulin Pump deliver insulin?

基礎胰島素 Basal insulin

- 用者只需要一種速效胰島素（例如 Aspart 或 Lispro），經過泵每分鐘輸注到皮下組織，代替了長效胰島素。

  Users only need a rapid-acting insulin (e.g. Aspart or Lispro) which is delivered continuously via the pump to replace long-acting insulin.

- 由於身體在不同時段需要的基礎胰島素劑量不同，我們可按個人需要設置不同的基礎胰島素輸注率。

  Since our body requires different amounts of basal insulin at different times of a day, basal insulin can be delivered at variable rates by the pump.

大劑量胰島素 Bolus insulin

控制餐後高血糖 Cover carbohydrate intake
- 進餐前，用者需輸入將會進食的碳水化合物量，泵就會輸出相應的餐前大劑量胰島素，去降低餐後高血糖狀況。

  Users have to enter the amount of carbohydrates they are going to consume; the pump will release a corresponding dose of bolus insulin to match the rise of glucose.

校正過高的血糖水平 Correct high blood glucose
- 當血糖讀數高過目標血糖值，用者只需輸入當時的血糖值，程式便會計算所需要的額外速效胰島素來校正高血糖。

  When the blood glucose reading is higher than target level, users have to enter the current blood glucose level, then the pump will calculate the correction dose.

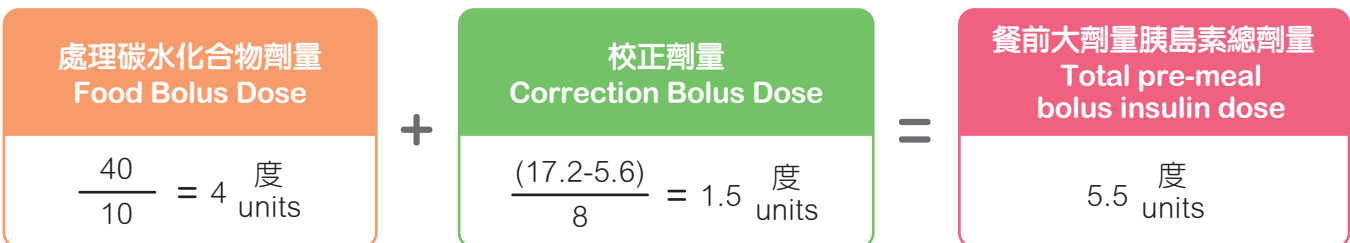| 胰島素／碳水化合物比值 Insulin-Carbohydrate Ratio (ICR)	用於計算處理碳水化合物劑量 For calculation of food bolus
	一度胰島素處理的碳水化合物量（克） The amount of Carbohydrates (CHO, in grams) that are covered by 1 unit of insulin
	例：胰島素／碳水化合物比值是10，意思是每進食10克的碳水化合物需要1度的速效胰島素 Example: ICR 10 means 1 unit of insulin will cover 10g of CHO
胰島素敏感系數 Insulin-Sensitivity Factor (ISF)	用於計算校正劑量 For calculation of correction bolus
	一度胰島素所能降低的血糖度數 The drop in blood glucose level
	例：胰島素敏感系數是4，意思是每一度胰島素將降低4mmol/L血糖 Example: ISF 4 means 1 unit of insulin will lower blood glucose by 4 mmol/L

餐前大劑量胰島素
Pre-meal bolus insulin dose

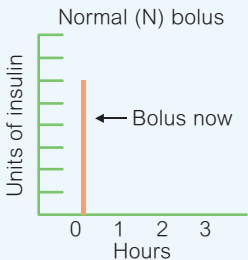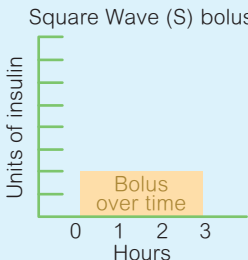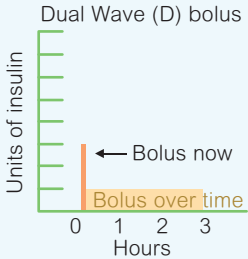| 處理碳水化合物劑量 **Food Bolus Dose**		校正劑量 **Correction Bolus Dose**		餐前大劑量胰島素總劑量 **Total pre-meal bolus insulin dose**
$\dfrac{碳水化合物（克）CHO\ (g)}{胰島素／碳水化合物比值\ ICR}$	**+**	$\dfrac{（現時血糖 - 目標血糖）(Current\ BG - Target\ BG)}{胰島素敏感系數\ ISF}$	**=**	

例子 Example

- 計劃吃**40**克碳水化合物 Plan to take **40**g of carbohydrates
- 現時血糖 Current BG: **17.2mmol/L**
- 目標血糖 BG target: **5.6mmol/L**
- 胰島素泵設定 Pump settings:
    - 胰島素／碳水化合物比值 Insulin-to-carb-ratio (ICR): **10**
    - 胰島素敏感系數 Insulin sensitivity factor (ISF): **8**

| 處理碳水化合物劑量 **Food Bolus Dose**		校正劑量 **Correction Bolus Dose**		餐前大劑量胰島素總劑量 **Total pre-meal bolus insulin dose**
$\dfrac{40}{10} = 4$ 度 units	**+**	$\dfrac{(17.2-5.6)}{8} = 1.5$ 度 units	**=**	5.5 度 units

大劑量類型
Special bolus types

| 大劑量類型 Types	原理 How it works	用途 When to use it
常規大劑量 Normal bolus Normal (N) bolus Units of insulin ← Bolus now 0 1 2 3 Hours	● 輸注單次指定劑量的胰島素 Provides a single immediate dose of insulin	● 用來處理低纖維，低蛋白質，低脂的碳水化合物食物（如白飯、水果…） To cover carbohydrate intake with low fibre, low protein or low fat ● 校正高血糖 To correct a high blood glucose reading
方波大劑量 Square wave Square Wave (S) bolus Units of insulin Bolus over time 0 1 2 3 Hours	● 在一段時間內（從30分鐘至8小時）均勻地輸注單次大劑量 Delivers a single bolus evenly over an extended period of time (30 minutes to 8 hours)	● 需要處理長時間消化的食物或延遲吸收的情況，如碳水化合物量較低但高脂肪食物 Conditions which require longer digestion or having delayed absorption (Meals with low carbohydrate but with high fat content) ● 進食時間較長的情況（如火鍋、燒烤…） Extended meal time (e.g. hotpot, barbeque...)
雙波大劑量 Dual wave Dual Wave (D) bolus Units of insulin ← Bolus now Bolus over time 0 1 2 3 Hours	● 輸注即時常規大劑量之後接著輸注"方波"大劑量 Delivers an immediate 'Normal' bolus followed by a 'Square Wave' bolus ● 一部份常規大劑量能對應即時升高的血糖，而剩餘的方波大劑量則有助於對應延遲升高的血糖 Normal bolus can cover immediate rise of blood glucose whereas the Square Wave can cover the delayed rise of blood glucose	● 進食碳水化合物和脂肪含量均高的食物（如意大利薄餅），因為脂肪會延長食物消化的時間 Meals that are both high in carbohydrates and fat (e.g. Pizza) as its high fat content may delay digestion

自動暫停功能
Low suspend function

葡萄糖值過低時—暫停輸注
Suspend on low

1.1 mmol/L above low limit

low limit

2 hours
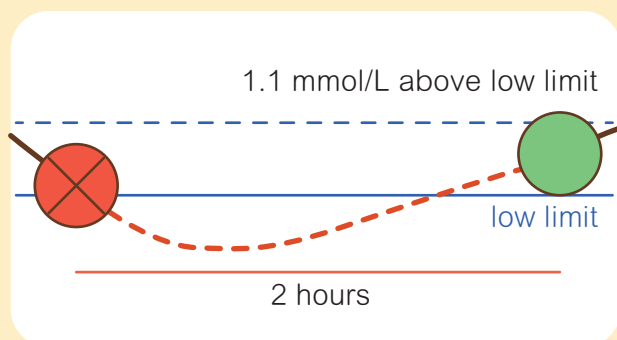
當感應器葡萄糖跌至已設定的下限時，即時暫停輸注胰島素。

The pump will temporarily stop delivering insulin if sensor glucose has reached or fallen below the low pre-set limit.

葡萄糖值過低前—暫停輸注
Suspend before low

3.9 mmol/L above low limit

1.1 mmol/L above low limit
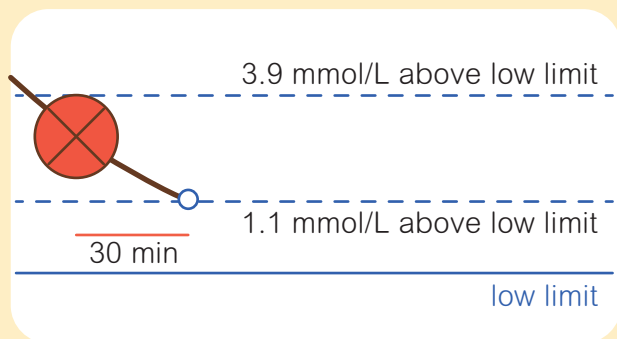
30 min

low limit

感應器葡萄糖預計於30分鐘內跌至已設定的下限時，暫停輸注胰島素。

The pump will temporarily stop delivering insulin if sensor glucose is predicted to reach or fall below the low limit in 30 minutes.

甚麼是活性胰島素？
What is active insulin time/insulin on board?
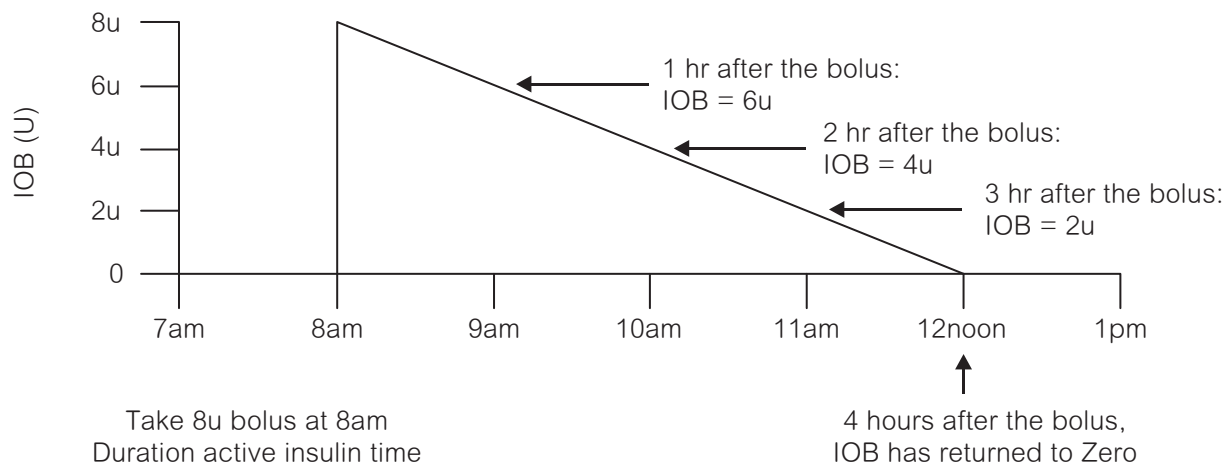
- 當輸注大劑量後，胰島素的活性程度會隨時間慢慢減至零。

  After a bolus is given, the amount of insulin that is 'active' in our body drops with time and reaches zero at the time set by the duration of 'active insulin time' value.

- 當再次輸注大劑量時，泵會按照當時的活性胰島素值，來調節劑量。

  The Pump's bolus calculator approximates this drop in insulin by calculating an 'insulin on board' (IOB) or 'active insulin' value.

- 例如：活性胰島素預設為4小時，我們在上午8時輸注8度大劑量，活性胰島素將會如下圖穩定地下降到零。

  For example, if your duration of 'active insulin time' is 4 hours and a bolus of 8 units was given at 8am, the IOB amount decreases steadily over time, as shown in the graph below.

1 hr after the bolus:
IOB = 6u

2 hr after the bolus:
IOB = 4u

3 hr after the bolus:
IOB = 2u

Take 8u bolus at 8am
Duration active insulin time

4 hours after the bolus,
IOB has returned to Zero

09

持續多天午餐後高血糖（反映大劑量胰島素不足）
Persistent high glucose level after lunch (indicates inadequate bolus insulin)

- 晴晴吃了60克碳水化合物作午餐，午餐前血糖6.5mmol/L。
  2小時後，血糖升至13mmol/L。
  Ching Ching took 60g CHO for lunch, her pre-lunch BG was 6.5mmol/L, glucose level rose to 13mmol/L after 2 hours.

- 解決方案：把她的ICR由15降至12，胰島素劑量便會由4度加至5度。
  Solution: Adjust ICR from 15 to 12, insulin dosage increased from 4u to 5u.

- 目標範圍：餐後2至3小時血糖上升2至3度。
  Target range: blood glucose increases by around 2-3mmol/L at post-meal 2-3 hours.

前 Before

碳水化合物 CHO	60g
胰島素／碳水化合物比值 ICR	15
胰島素劑量 Dose	4u

ICR 15 → 12

後 After

碳水化合物 CHO	60g
胰島素／碳水化合物比值 ICR	12
胰島素劑量 Dose	5u

校正後時常低血糖（反映校正劑量過多）
Low glucose level after correction dose (indicates excessive correction bolus)

- 朗朗校正前的血糖讀數為14 mmol/L，目標血糖為5.6mmol/L，但校正後血糖跌至3.2mmol/L。
  Long Long's current BG was 14mmol/L, and target BG was 5.6mmol/L. After correction, BG drops to 3.2mmol/L.

- 解決方案：把他的ISF由4提高至5後，校正劑量便會由2.1度減至1.7度，以避免過度校正和低血糖。
  Solution: Adjust the ISF from 4 to 5, less insulin would then be given (from 2.1u to 1.7u) to avoid excessive correction and low blood glucose.

- 注意：混合／半閉環系統使用者不需調教胰島素敏感系數。
  Note: no ISF adjustment would be needed/ allowed if using hybrid-closed loop system.

前 Before

現時血糖 Current BG	14
目標血糖 ICR	5.6
胰島素敏感系數 ISF	4
校正劑量 Correction dose	2.1u

ISF 4 → 5

後 After

現時血糖 Current BG	14
目標血糖 ICR	5.6
胰島素敏感系數 ISF	5
校正劑量 Correction dose	1.7u

午夜高血糖（反映基礎胰島素劑量太少）
# High glucose overnight (indicates inadequate basal insulin rate)

- 盈盈午夜時血糖持續偏高。
  Ying Ying experienced high glucose overnight.

- 解決方案：
  午夜12:00至早上7:00期間的基礎胰島素率由每小時0.7提高至0.8度，血糖便會在午夜維持目標水平。
  Solution: Raise the basal insulin rate from 0.7u per hour to 0.8u per hour, in order to keep overnight glucose level in the target range.
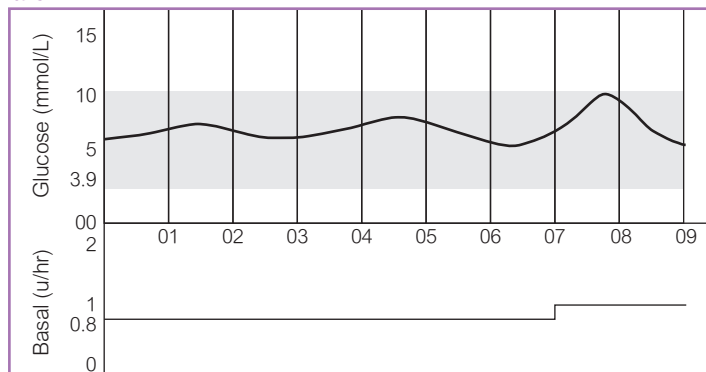
- 注意：
  混合／半閉環系統使用者不需調教基礎胰島素率。
  Note: No basal rate adjustment would be needed/ allowed if using hybrid-closed loop.

前 Before
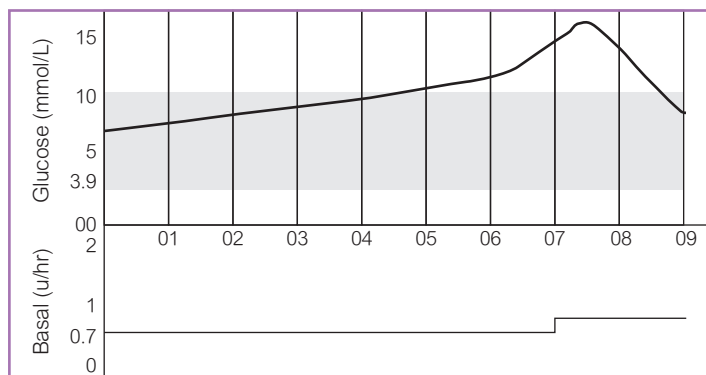
**12am > 7am
Basal Rate
0.7 u/hr → 0.8 u/hr**

後 After

12

運動小貼士
Exercise tips

01

在運動期間密切留意感應器葡萄糖變化。
Close monitoring of sensor glucose during exercise.

02

水上運動時，不要停止連接胰島素泵超過一小時。
For water sports: do not disconnect insulin pump for more than 1 hour.

03

臨時目標值
Temporary target

- 運動時，使用半閉環系統的用者可以設置至較高的臨時目標值（例：8.3mmol/L）
  For patients using the hybrid-closed loop system, a temporary target can be set at a higher level (e.g. 8.3 mmol/L) during exercise.

- 你可延長較高的臨時目標值（可能延至整個晚上），或於進行強度較高／時間較長的運動時補充額外的碳水化合物。
  You can also consider setting the higher temporary target for a longer period (possibly overnight) or consume extra carbohydrates for intense/ long duration of exercise.

- 你亦可因應運動的強度和時間提前設定臨時目標值。
  Depending on the intensity and duration of exercise, you may set the higher temporary target before exercise starts.

04

臨時基礎率
Temporary basal rates

- 在運動時，可設置或預設臨時基礎率，以穩定血糖水平。
  During exercise, a temporary basal rates can be set to stabilise blood glucose levels.

- 臨時基礎率可設置為30分鐘至24小時。時間結束後，原本的基礎率會自動恢復。
  Temporary basal rate can be set for 30 minutes to 24 hours. It will automatically return to original basal rate afterwards.

- 你亦可以因應運動強度，在運動30分鐘前轉換至臨時基礎率。
  Temporary basal rate can be set 30 minutes before exercise starts, depending on the exercise intensity.

（注意：混合／半閉環系統使用者不需調教臨時基礎率）
(Note: For hybrid-closed loop system users, temporary basal rate is not needed)

05

使用臨時目標值後，如葡萄糖值仍然低，可以考慮暫停胰島素泵或轉用手動模式，轉至臨時基礎率和啟動低感應器葡萄糖值前暫停輸注。
If lows persist even with use of temporary target, consider suspending the pump for part of the exercise time, or change to manual mode with temporary basal rate and turn on suspend before low function.

06

如有突發活動，而葡萄糖低於5mmol/L時，請在活動前補充易於吸收的碳水化合物。
If there is unplanned activity and glucose is less than 5mmol/L, consider consuming some simple sugar before the start of activity.

使用胰島素泵和
連續式葡萄糖監測裝置的小貼士
Tips for using an Insulin Pump and CGMS

胰島素輸注 Delivery of insulin

準確地計算碳水化合物量，盡量於餐前（5至15分鐘）輸注餐前大劑量胰島素。
Accurate carbohydrate counting and try to give meal bolus (5-15 mins) before every meal.

回應胰島素泵發出的警報和提示。
Respond to alerts and prompts from the pump.

高血糖時，按照指示輸注校正劑量。
Give a correction dose as instructed when having high glucose level.

忘記餐前輸注大劑量胰島素：
If a bolus is forgotten before meal:

- 如果仍在進食後一小時內：
  輸入已進食碳水化合物克數的一半，並在兩小時後重新檢查血糖值。如果血糖值仍在高水平，請輸入當前血糖值，並根據泵的指示輸注校正劑量。
  Within 1 hour after eating:
  Enter half of the grams of carbohydrates eaten and recheck blood glucose after 2 hours. If glucose level is still high, enter the current blood glucose level and give the recommended correction bolus.

- 如果已進食超過一小時：
  請輸入當前血糖值，並根據泵的指示輸注校正劑量。
  More than 1 hour after eating:
  Enter the blood glucose and give the recommended correction bolus.

校準連續式葡萄糖監測裝置 Calibration of CGMS

💡 視乎連續式葡萄糖監測裝置型號：某些型號每天最少校準兩次
（即每12小時一次），建議在睡前和上課前校準。
Depending on the model of CGMS: Some models require calibration at least 2 times a day
(i.e. every 12 hours), preferably before going to bed and attending classes.

💡 校準時，應即時輸入血糖值，並避免在葡萄糖水平波動時校準（例如飯後、輸注快性
胰島素後、運動期間）
Enter a blood glucose reading immediately for calibration and DO NOT calibrate when glucose
level is fluctuating (e.g., after meals, after giving a bolus, during exercise).

💡 你可以設置校準提示，提醒自己稍後進行校準。
You can set a snooze to remind calibration later.

💡 應在有重要活動前（如考試前）進行校準。
You should calibrate before important activities (e.g., before an exam)

睡前建議 Before going to bed

💡 避免更換連續式葡萄糖監測裝置或胰島素輸液器。
Avoid changing CGMS sensor and insulin infusion set.

💡 睡前先作校準。
Calibrate CGMS before sleep.

💡 如果睡前血糖偏低（4-5mmol/L），你可以進食小食（5-10g）以稍微提高
血糖，以免因基礎胰島素輸注過少而退出自動模式。
If glucose is on low-side (e.g. 4-5mmol/L before sleep), consider taking a
small snack (5-10g) to prevent CGMS exiting from auto-mode.

💡 如果血糖過高，請根據泵的指示輸注校正劑量。
If glucose is high, consider correction bolus before sleep.

旅遊時 Travelling

💡 攜帶有關使用胰島素泵和連續式葡萄糖監測裝置的醫生信，並通知機場保安人員和航空公司職員。
Bring your medical certificate for the use of insulin pump and CGMS, and notify security personnel and contact aviation authority

💡 在檢查手提行李時，讓工作人員以目視檢查所有儀器，不要使用X光安檢機。
During hand/carry-on luggage examination, request the security personnel to visually inspect the equipment, do not send your devices through the X-ray machine.

💡 全身掃描儀可以是X光的一種形式，在通過掃描之前請移除感應器和傳送器，或要求另一種檢查方式代替全身掃描儀。
The whole body scanner could be a form of X-ray. Remove the sensor and transmitter prior to the scan or request an alternative screening process.

💡 隨身攜帶所有泵配件，包括感應器、傳送器、額外的胰島素泵輸液器等、胰島素筆等。
Hand-carry all pump-related accessories, including sensors, transmitter, extra pump infusion sets/reservoirs and insulin etc.

💡 攜帶額外的胰島素筆和針頭（泵故障時使用）。
Bring extra insulin pens and pen needles (to be used at times of pump failure).

💡 攜帶用於儲存胰島素的冷藏袋。
Bring a cooler bag for storing insulin.

💡 抵達目的地時，根據當地時區更改泵的時間。
Upon arrival, adjust the time of the pump to the correct time zone.

胰島素泵的優點
Potential Advantages of an Insulin Pump

- 減少注射次數
  Fewer injections

- 提升生活自由度
  Flexibility

- 減少低血糖情況的發生
  Less hypoglycaemia

- 胰島素注射劑量更精準
  Precision of insulin dosage

- 個人化
  Individualisation

- 改善生病或運動期間的血糖控制
  Better glycaemic control during illness or exercise

胰島素泵的缺點
Potential Disadvantages of an Insulin Pump

- 連接問題
  Connection problems
    - 如葡萄糖感應器讀數因信號問題未能傳送到胰島素泵／手提電話
      Sensor glucose readings cannot be sent to insulin pump/mobile phone due to signal problem

- 酮酸中毒的風險
  Risk of diabetic ketoacidosis
    - 因為泵故障、喉管扭結、移位、堵塞、氣泡
      Due to pump malfunction, kinking, set dislodgement, tube blockage or bubbles

- 皮膚敏感或感染
  Skin irritation and infection

- 頻繁的血糖測試
  Frequent blood glucose testing

- 放置輸液器時的疼痛和恐懼
  Pain and fear of infusion set insertion

- 胰島素泵和相關物資價格高昂
  High cost of insulin pump and accessories

- 醫療廢物
  Medical wastes

給家長的話 Message to parents:

我的孩子適合使用泵嗎？✓ 或 ✕
Is an insulin pump right for my child? ✓ or ✕

- ☐ 孩子怎麼想？尊重他／她的決定！
  What does he/she think? Respect his/her decision!

- ☐ 願意一直將泵連接到皮膚上
  Willing to be attached to the pump most of the time

- ☐ 願意計算碳水化合物
  Willing to do carbs counting

- ☐ 願意回應警報
  Willing to respond to alarms

- ☐ 了解甚麼是泵故障以及如何處理
  Understand what pump failure is and its management

⭐ 糖尿技術不是萬能的，泵／新技術未必適合所有人
Diabetes technology is not the solution for everything, pump/ new technology might not be suitable for everyone

⭐ 即使有糖尿新技術，仍要接受血糖控制的不完美
Even with new diabetes technology, we should accept some imperfections in blood glucose control

⭐ 胰島素泵只是治療選擇之一
Insulin pump is just one of the treatment options

⭐ 許多採用傳統的胰島素注射治療的糖尿病小朋友，也能達到良好的血糖控制
Many children with diabetes can achieve good glucose control with traditional insulin injection regimen

⭐ 如果胰島素泵適合你的孩子，請諮詢你的醫護人員，了解更多詳情
If an insulin pump is right for your child, please speak to your health professional/ doctor to find out more

溫馨提示：技術與時俱進，未來可能會有進一步的細節修改
Warm reminder: Technology keeps improving with time and there would be modifications in the future

January 2023