Glucagon stimulation test(GST)

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1. 目的： 評估 β 細胞功能。

2. 執行流程：

(1) 住院當晚 midnight NPO (since 0:00am), 隔日 9:00am 開始做檢查

(2) Dose of IV glucagon: 0.03mg/kg/dose (Max 1mg)

(3) 抽血時間點與項目：

時間（分）	F/S	Blood sugar	Insulin	C-peptide
0	V	V	V	V
Glucagon IV				
3	V	V	V	V
6	V	V	V	V
10	V	V	V	V
15	V	V	V	V
20	V	V	V	V
30	V	V	V	V
40	V	V	V	V
50	V	V	V	V
60	V	V	V	V

*若已接受 insulin 治療，則不驗 insulin。

*Maldonado M, et al, 2003: 檢驗時間是 0, 5, 10 min。

3. Interpretation:

(1) ΔCP(increment of serum C-peptide during glucagon test)

- ✧ IDDM: ΔCP ≦ 0.69 ng/ml
- ✧ NIDDM: ΔCP ≧ 1.20 ng/ml

(2) Maldonado M, et al 2003

- ✧ B-Cell functional reserve was defined as preserved if the peak C-peptide response to glucagon was at least 1.5 ng/dl (0.5 nmol/liter) or fasting C-peptide concentration was at least 1 ng/dl (0.33 nmol/L).
- ✧ B-Cell functional reserve was defined as absent if the glucagonstimulated or fasting C-peptide concentrations did not meet these criteria.

(3) Yi-Ching Tung, Wen-Yu Tsai, et al, 2009:

Table 1. Clinical characteristics of patients with type 1 diabetes

Age (yr)	0–5 ($n=40$)	5–10 ($n=66$)	10–18 ($n=51$)	Total ($n=157$)	p
Sex (male:female)	18:22	23:43	19:32	60:97	0.574¶
HbA1c*	12.1 (7.8–16.8)	12.3 (6.2–17.3)	13.7 (6.1–18.5)	12.5 (6.1–18.5)	<0.001‡
Ketoacidosis†‡	35 (90)	42 (65)	26 (52)	103 (67)	0.001¶
C-peptide (nmol/L)*					
Fasting	0.14 (0.1–0.49)	0.17 (0.1–1.31)	0.24 (0.1–1.19)	0.19 (0.1–1.31)	0.003‡
Post-glucagon	0.17 (0.1–0.92)	0.32 (0.1–1.98)	0.39 (0.1–2.09)	0.30 (0.1–2.09)	<0.001‡
GADA positivity‡	31 (78)	45 (68)	38 (75)	114 (73)	0.544¶
IA-2A positivity‡	30 (75)	50 (76)	40 (78)	120 (76)	0.917¶
IAA positivity‡	18 (45)	8 (12)	7 (14)	33 (21)	<0.001¶
Multiple antibodies‡§	29 (72)	39 (59)	32 (63)	100 (64)	0.377¶
No detectable antibodies‡	1 (3)	8 (12)	4 (8)	13 (8)	0.219¶

**Data presented as mean (range); †one missing data in each age group; ‡data presented as n (%); §more than two β-cell autoantibodies were detected; ‡Kruskal–Wallis test; ¶Pearson's χ^2 test. HbA1c = hemoglobin A1c; GADA = glutamic acid decarboxylase autoantibody; IA-2A = insulinoma antigen-2 autoantibody; IAA = insulin autoantibody.*

- ✧ Post-glucagon means: the C-peptide level 6 mins after glucagon injection.
- ✧ C-peptide: 1 ng/dL=0.33nmol/L
- ✧ 換算單位為 ng/dL 之參考值整理如下：

Age	0-5	5-10	10-18
Fasting C-peptide (ng/dL)	0.3-1.47	0.3-3.93	0.3-3.57
Post-glucagon C-peptide (ng/dL)	0.3-2.76	0.3-5.94	0.3-6.27

4. **For transient hyperglycemia and prediabetes:** 0.03 mg/kg of glucagon (max. 1 mg) was injected through i.v. Baseline and peak C-peptide level were measured at 0 and 6 min, respectively.

Reference:

Ting Chao, Shih-Tzer Tsai, Tian-Shing Lee, Betau Hwang: Clinical implication of transient hyperglycemia in childhood. ActaPaed Sin 1996; 37: 444-7.

4. Reference:

(1) Juang JH, Huang BY, Huang HS, Lin JD. C-peptide response to glucagons in young diabetics.*J Formosan Med Assoc.* 1989;88:579-583.

(2) Hwang JS, Juang JH. Clinical courses and changes of pancreatic β-cell function in young-onset diabetes: Report of two cases. Chang Gung Med J 1998;21:328-332.

(3) Maldonado M, et al. Ketosis-prone diabetes: dissection of a heterogeneous syndrome using an immunogenetic and b-cell functional classification, prospective analysis, and clinical outcomes. *J ClinEndocrinolMetab*. 88: 5090–5098, 2003
(4) Yi-Ching Tung, Mei-Huei Chen, Cheng-Ting Lee, Wen-Yu Tsai1. β-Cell Autoantibodies and Their Function in Taiwanese Children With Type 1 Diabetes Mellitus. *J Formos Med Assoc.* 2009; 108:11