

檢驗與慢性腎臟病

Laboratory Tests and Chronic Kidney Disease

臺北榮民總醫院

內科部腎臟科 林志慶

國立陽明大學內科學教授



National Yang-Ming University



內容概要

- 個案介紹
- 慢性腎臟病的定義
- 腎臟功能評估的方法
- 慢性腎臟病的分期
- 慢性腎臟病的整體照護觀念

個案介紹

一位68歲女性, 主述於老人健檢發現BUN 19 mg/dl, Cr 1.4 mg/dl, FBS=108 mg/dl, 蛋白尿+, 並無臨床症狀, 診所醫師建議他到醫院檢查, 結果:

BP 150/90 mmHg, 體重42公斤, BUN 22 mg/dl, Cr 1.4 mg/dl, FBS=112 mg/dl, proteinuria (+), 尿酸 8.2 mg/dl, 膽固醇 248 mg/dl, TG 257 mg/dl. 接下來您應該

- (1) 安排那些進一步的檢查?
- (2) 建議如何治療?
- (3) 建議異常數值的控制目標為何?

內容概要

- 個案介紹
- 慢性腎臟病的定義
- 腎臟功能評估的方法
- 慢性腎臟病的分期
- 慢性腎臟病的整體照護觀念

慢性腎臟疾病的定義

● 經診斷檢查，證實腎臟
結構（病理或影像學檢查）異常或
功能（血液或尿液檢查）異常

或

● 腎絲球過濾率(GFR) 小於每分鐘60毫升
(cc/min/1.73m²)

超過三個月

內容概要

- 個案介紹
- 慢性腎臟病的定義
- 腎臟功能評估的方法
- 慢性腎臟病的分期
- 慢性腎臟病的整體照護觀念

Table 142. Laboratory Evaluation of Patients with Chronic Kidney Disease

All Patients

Serum creatinine to estimate GFR

Protein-to-creatinine ratio or albumin-to-creatinine ratio in a first-morning or random untimed "spot" urine specimen

Examination of the urine sediment or dipstick for red blood cells and white blood cells

Imaging of the kidneys, usually by ultrasound

Serum electrolytes (sodium, potassium, chloride and bicarbonate)

腎臟病異常臨床檢驗值

1. 生化數值判讀
2. 電解質判讀
3. 尿液數值判讀
4. 24小時尿液檢驗之判讀

生化數值判讀

● 尿素氮(BUN)：7-20 mg/dl

● 肌酸酐 (Creatinine, Cr):

男性 0.7-1.5mg/dl,

女性 0.5-1.2mg/dl

● 尿酸(Uric acid, UA):

男性 2.5-7.2 mg/dl,

女性 1.8- 6.2mg/dl

電解質檢查 (1)

- 鈉: Na 135~147mmol/L
- 氯: Cl 100~114mmol/L
- 鉀: K 3.5~4.7mmol/L
- 鈣: Ca 8.4~10.6 mg/dl
- 磷: I.P 2.1~4.7mg/dl
- 鎂: Mg 1.7~2.7 mg/dl
- 重碳酸鹽: $[\text{HCO}_3^-]$ 22~26 mEq/L

尿液數值判讀：尿液試紙測試

- 尿液酸鹼(pH)值：正常值約為5~8。
- 蛋白質：為腎臟病的重要指標。
- 潛血：一般情形下尿液中是不會有潛血反應的。
- 尿比重：正常的尿比重在1.005-1.030。
- 葡萄糖：當血糖濃度超過 160 ~ 180 mg/dl 時，尿糖可能呈陽性。

尿液數值判讀:尿液沈渣檢查

正常人的尿液細胞數目如下:

- 紅血球：2個以下
- 白血球：5個以下

尿液細胞異常之定義:

- 血尿:紅血球 3個以上
- 膿尿:白血球 5個以上

表示可能有腎臟病，須進一步檢查治療。

24小時尿蛋白量

- 正常每天尿蛋白量應少於150 mg
- 泡沫狀小便並不一定代表有蛋白尿。
- 對於有持續性蛋白尿者則需要進一步的追蹤和檢查。

Estimation of Daily Proteinuria by Single Voided Urine

❖ **Protein/creatinine ratio** in a single urine sample: *New Engl J Med 1983 (309): 1543*

- * More than 3.5 : nephrotic range proteinuria
- * Less than 0.2: within normal limits

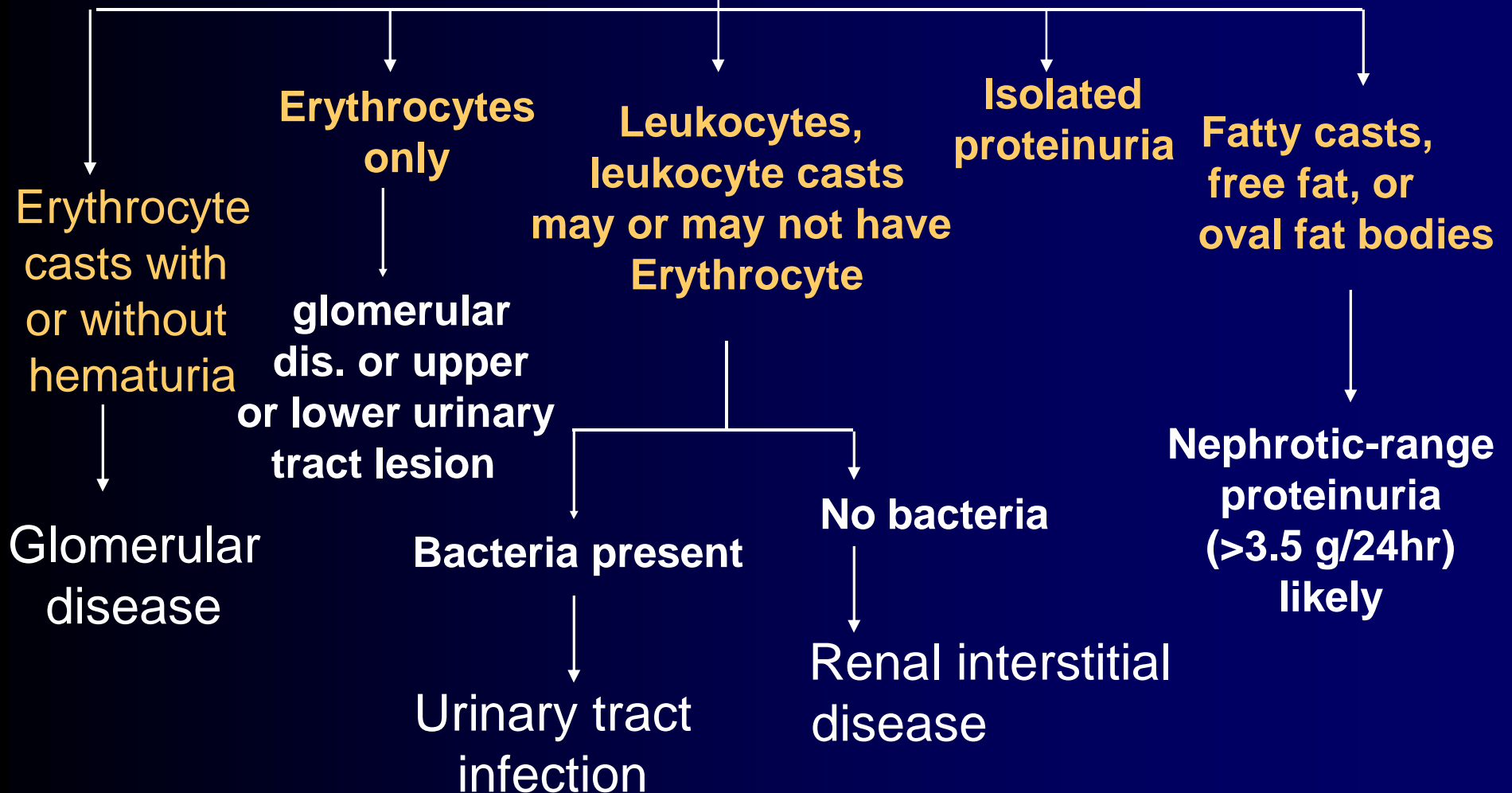
❖ **Protein/Osmolality Ratio**: Clin Chem 1992 (100): 419

- * Normal value < 0.12 (sen. 96%, spe. 93%)
- * Ratio $> 2.5 \Rightarrow$ 24 Hr Up > 3 gm (sen. 91%, spe. 98%) better than protein/Cr ratio in predicting 24 hours urine protein

Urinalysis

Proteinuria

Microscopic examination of urine



正常尿液成份與生化值

- pH 4.7 ~7.8
- Osmolality > 800 mOsm/L (under fasting)
- specific gravity 1.005~1.030
- Albumin <30 mg/day
** **Microalbuminuria:**
urine albumin 30~300 mg/day
- Total bilirubin: (-)
- Glucose < 300 mg/L
- Ketone < 50 mg/L
- Urobilinogen < 1mg/L
- Urea nitrogen (UUN): 7~16gm/day
- Uric acid 300~800 mg/day
- Phosphorus 900~1300 mg/day
- Potassium 30~100 mEq/day
- Sodium 85~250 mEq/day
- Protein < 150 mg/day
- Calcium 100~240 mg/day
- Creatinine (mg/day): 0.8~1.2 times
(28- Age/5) x BW for male;
(24- Age/6) x BW for female

尿素氮 (Blood Urea Nitrogen: BUN)

1. Characteristics of urea

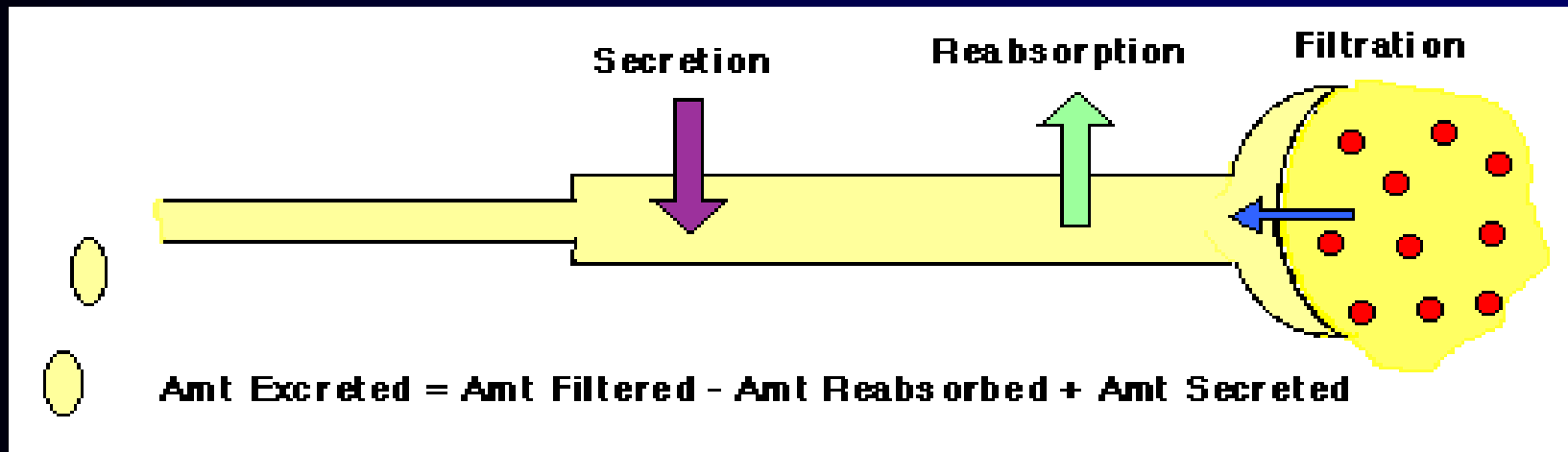
- * The primary end product of protein metabolism
- * The major form of nitrogen removed by the body
- * Comprised ~90% of the total nitrogen in the urine
- * Not protein-bound and freely filtered by the glomeruli
- * A variable degree of **tubular reabsorption** both in the proximal and distal tubule that is heavily dependent on urine flow => **clearance of urea (C_{urea}) < GFR**

2. Normal value of BUN: 8~ 20 mg/dl

肌酸酐 (Creatinine)

- Normal serum value: 5 years: 0.6 mg/dl (x 88 in $\mu\text{mol/L}$)
 - * 40 years: 1.2 ~ 1.3 mg/dl; 10% higher in male > female
 - * falling during pregnancy
- Characteristics:
 - * the breakdown product of creatine in muscle
 - * not protein-bound in plasma
 - * totally cleared by the glomerulus
 - * variable degree of **proximal tubular secretion**
=> **Clearance of creatinine (CCr) > GFR**
- The mostly widely utilized laboratory test for estimation of renal function
- Disadvantage: not sensitive for detection of mild renal insufficiency (GFR= 50~90 cc/min/1.73m²)

腎絲球過濾率 (GFR)



- 排出量 = 過濾量 + 分泌量 - 再吸收量
- 廓清率 (clearance) = 腎絲球過濾率 + 分泌速率 - 再吸收速率)
= 尿中濃度(mg/dl) x 24小時尿液總量(毫升)
÷ [1440(分鐘) x 血中濃度(mg/dl)]
- Inulin分泌速率 = 再吸收速率 ∴ Inulin 廓清率 = 腎絲球過濾率
- 肌酸酐分泌速率 > 再吸收速率 ∴ 肌酸酐廓清率 > 腎絲球過濾率
- 尿素氮分泌速率 < 再吸收速率 ∴ 尿素氮廓清率 < 腎絲球過濾率
- **CCr > GFR (Cinulin) > Curea**

Creatinine的特性

- Extra-renal Cr excretion:
 - * minimal in normal renal function
 - * increased in CKD due to the degradation of Cr by bacterial overgrowth in the small bowel
 - * ~ 2/3 of total Cr excretion in severe renal failure
- Overestimation of GFR from serum creatinine
- Serum Cr < 2.0 mg/dL despite GFR ~ 15 to 20 mL/min/1.73 m²
- An insensitive index of decreased GFR
- 40% of individuals with ↓GFR had normal [Cr]

Creatinine 的測定 (1)

- Normal level in young adults ~ 1.0 mg/dL
- Alkaline picrate method: detecting non-Cr chromogens & Cr in serum (~0.2 mg/dL).
- **Jaffe** and modified Jaffe reaction methods:
in patients with low muscle mass & serum Cr 1.0 mg/dL
→ 和 high performance liquid chromatography & dilution mass spectrometry 相比 → 高估血液 [Cr] 達 20 to 80%
- 尿液不含 non-Cr chromogens
- Measured CCr underestimated true CCr (due to higher measured serum Cr).
- Δ (true CCr - **measured CCr**) \equiv Δ CCr due to tubular secretion (true CCr - **GFR**). Hence, measured CCr has historically approximated the level of GFR.

Creatinine 的測定 (2)

- 比較不受 non-Cr chromogens 干擾的測定法: kinetic alkaline picrate or the imidohydrolase method (enzymatic methods).
- 因此目前的serum Cr 正常值較低, 導致 higher values for measured CCr 並高估 GFR.
- 為使高估GFR的情形降到最低, autoanalyzer廠商與clinical laboratories 可能校正調高Cr測定值.
- 此一Cr校正值並未經過標準化, 導致variation within and across laboratories.
- Cr 值較低時, variation 的比例反而較高.

影響Creatinine測定的因素

- The level of GFR
- Age
- Gender
- Race
- Body size
- Diet
- Certain drugs
- Laboratory analytical methods

BUN/Cr Ratio

BUN/Cr > 20:1

- Volume depletion
- Decreased renal perfusion (CHF, hypoalbuminemia)
- Protein loading
- GI bleeding
- High catabolic rate
- Corticosteroid
- Outdated tetracycline
- Decreased muscle mass

BUN/Cr < 10:1

- Volume expansion (SIADH)
- Cirrhosis; ; vigorous exercise
- Protein malnutrition
- Rhabdomyolysis
- Anabolic steroid
- Creatine supplement
- Blocked tubular secretion: trimethoprim, cimetidine, aspirin
- Assay interference: methyldopa, cephalosporins, flucytosine, ketosis, levodopa, ascorbic acid
- Dialysis recently performed

腎絲球過濾率

Glomerular Filtration Rate (GFR)

- GFR: male 131 ± 18 cc/min, female 120 ± 14 cc/min per 1.73 m^2 body surface area; normally decreasing rate is 0.4 cc/min/yr after 20 y/o or 1 cc/min/yr after 40 y/o
- Higher GFR in afternoon, increase in pregnancy, early DM, amino acid intake, ECF expansion
- Lower GFR in use of **trimethoprim or cimetidine**
- **Most accurate GFR:**
 - * **Clearance of Inulin (Cin)**
 - * **radiolabeled ^{125}I -iothalamate , * $^{99\text{m}}\text{Tc}$ -DTPA, ^{51}Cr -EDTA**

Clearance of Inulin

- Inulin: a kind of fructose polysaccharide excreted into urine only by filtration but not by reabsorption or secretion
- Gold standard of measuring GFR
- 缺點：麻煩且費時費力
 - *需要 intravenous infusion
 - *需要數小時的時間收集尿液

Inulin Clearance (廓清率)

- The **gold standard** for measuring GFR
- In healthy hydrated young adults:
127 \pm 20 ml/min/1.73 m² in men
118 \pm 20 ml/min/1.73 m² in women
- Among adults, glomerular filtration rate is lower at older ages.
- After age 20 to 30 years, GFR↓by ~ 1.0 ml/min/1.73 m² /yr with inter-individual variations.
- Whether this GFR decline with aging predicting the risk of complications and mortality is unknown.

評估腎絲球過濾率的核子醫學檢查

- **^{125}I -iothalamate & $^{99\text{m}}\text{Tc}$ -DTPA**
(DiethyleneTriamine-Pentaacetic Acid) :
urinary clearance provide excellent measures
of GFR but are not readily available.
- Plasma clearance of iohexol and **^{51}Cr -EDTA**
require estimates of body size, which
decreases their precision.

肌酸酐廓清率

(Creatinine Clearance: CCr)

- Involved process of clearance: glomerular filtration, tubular reabsorption and secretion, metabolism
- 肌酸酐廓清率(ml/min)=
尿中肌酐酸濃度(mg/dl) x 24小時尿液總量(ml)
÷ [1440(min) x 血中肌酐酸濃度(mg/dl)]
- 預估肌酸酐廓清率 **(Cockcroft-Gault)** (ml/min)=
男性：(140－年齡) x 體重 (公斤) ÷ (72 x 血中肌酸酐濃度)；
女性：(140－年齡) x 體重 (公斤) ÷ (72 x 血中肌酸酐濃度) x **0.85**
- 正常男性的肌酸酐廓清率為100~125 ml/min，女性為95~110 ml/min。

腎功能試驗

- CCr overestimates GFR:
 - ~10% in GFR >70 cc/min
 - ~ 10~50% in GFR 40~70 cc/min
 - ~ 50~100% in GFR <40 cc/min
- **Estimated CCr (Cockcroft-Gault)**
= (140 -age)x BW ÷ (72x Cr) in male; x 0.85 in female
- Urea is reabsorbed 40~50% in normal renal function,
so **Curea is 40~50% underestimation of GFR**
- Moderate to advanced renal disease with PCr > 2.5 mg/dL: $GFR = (CCr + Curea) / 2$
(the most practical equation to estimate GFR)

CG公式試算

$$\text{估計GFR} = \frac{(140 - \text{年齡}) \times (\text{理想體重kg})}{\text{血清Cr} \times 72}$$

(1) 70歲男性75 kg，血清肌酸酐1.2 mg/dl

$$\text{Ccr} = \frac{(140 - 70) \times 75}{1.2 \times 72} = 60.76 \text{ ml/min}$$

【CKD stage 2】

(2) 70歲女性40 kg，血清肌酸酐1.2 mg/dl

$$\text{Ccr} = \frac{(140 - 70) \times 40}{1.2 \times 72} = 32.4 \text{ ml/min}$$

$$32.4 \times 0.85 = 27.54 \text{ ml/min} \quad \text{【CKD stage 4】}$$

腎絲球過濾率 (GFR) 公式

(1) Cockcroft-Gault 公式:

$$\text{eGFR} = \frac{(140 - \text{Age}) \times \text{BW (Kg)} \times 0.85 (\text{if female})}{\text{肌酸酐} \times 72}$$

(2) Simplified MDRD 公式=

$$186 \times \text{Scr}^{-1.154} \times \text{Age}^{-0.203} \times 0.742 (\text{if female}) \times 1.212 (\text{if black patient})$$

正式名稱: 4-variable Modification of Diet in Renal Disease (MDRD) Study equation

eGFR 單位 ml/min (/1.73 m²)

Table 48. Abbreviated MDRD Study Equation

Estimated GFR (ml/min/1.73m²)

$$= 186 \times (S_{Cr})^{-1.154} \times (Age)^{-0.203} \times (0.742 \text{ if female}) \times (1.210 \text{ if African-American})$$

$$= \exp(5.228 - 1.154 \times \ln(S_{Cr}) - 0.203 \times \ln(Age) - (0.299 \text{ if female}) + (0.192 \text{ if African-American}))$$

planation, see text and references 17,18.

網址 <http://mdrd.com/>

MDRD GFR Calculator - (With SI Units)

4 variable MDRD Study equation using serum creatinine, age, race, gender

by Stephen Z. Fadem, M.D., FACP, FASN

Serum creatinine

☒ mg/dL ☐ μ mol/L

☐ Creatinine
methods recalibrated
to be traceable to
IDMS. (What is this?)

1.2

Age

68 years

Race

☐ African American ☒ All other races*

Gender

☒ Male ☐ Female

GFR Value: 64 mL/
min/1.73 m²

Check if kidney damage for at least three months

☐

評估華人腎絲球過濾率的公式

$$\begin{aligned} \text{GFR (ml/min/1.73m}^2\text{)} \\ &= 175 \times \text{Cr}^{-1.234} \times \text{age}^{-0.179} \\ &\quad \times (0.79 \text{ if female}) \end{aligned}$$

Plasma Cr (mg/dl) levels were measured in a single laboratory (normal reference range, 0.72–1.48 mg/dl or 64–131 $\mu\text{mol/l}$) on a Hitachi 7600 analyser using the Jaffe's kinetic method with a sample blank.

Ma Y-C, Zuo L, Chen J-H, Luo Q, Yu X-Q, Li Y.
J Am Soc Nephrol 2006; 17:2937–2944

MDRD公式之特點

- 用於成人
- 提供臨床上實用之GFR估計值 (range up to 90 mL/min/1.73 m²)
- 優點:
 1. having been derived based on GFR measured directly by urinary clearance of ¹²⁵I-Iothalamate
 2. a large sample of >500 individuals with a wide range of kidney diseases
 3. inclusion of both European-American and African-American participants
 4. validated in a large (n > 500) separate group of individuals as part of its development

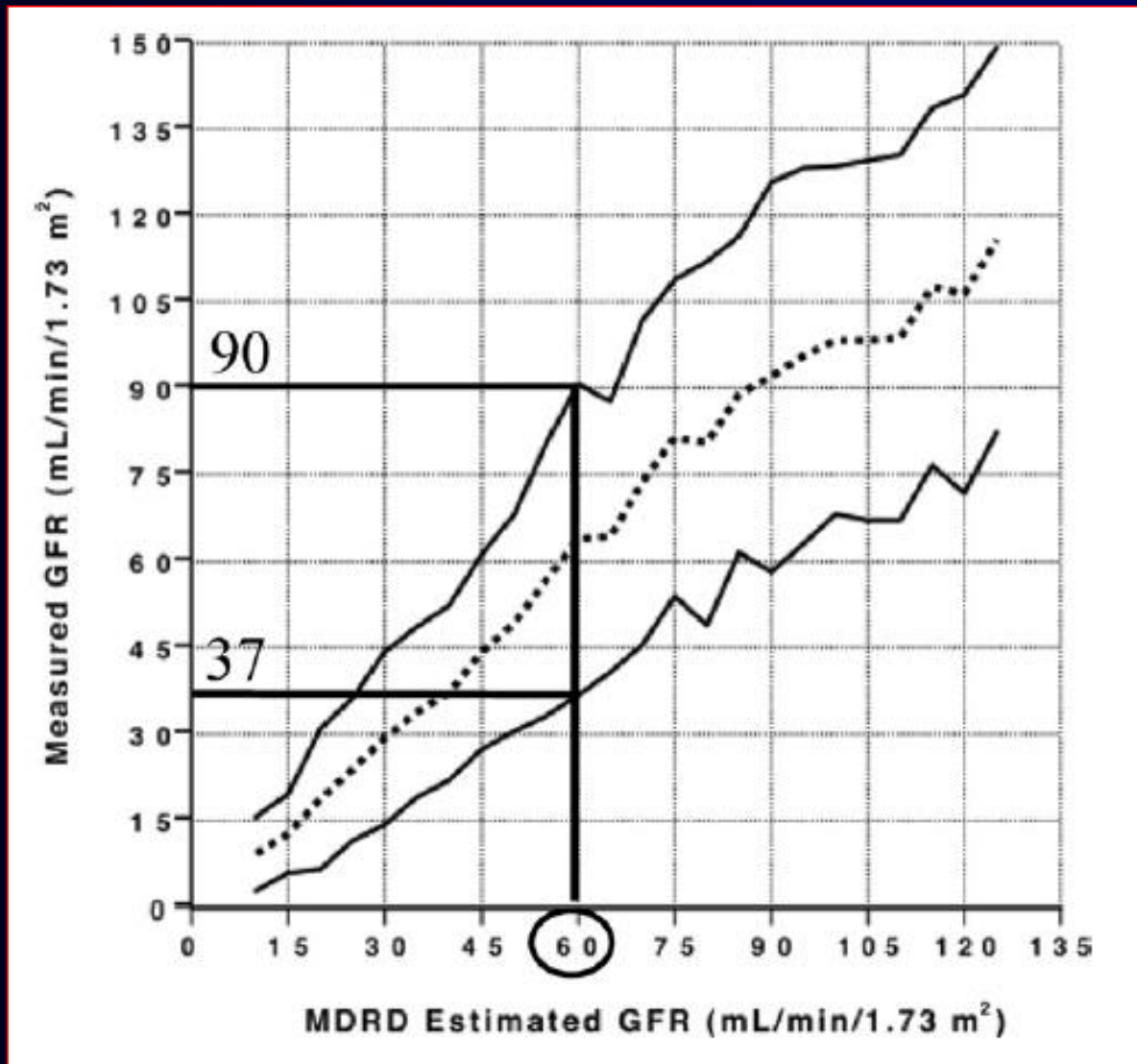
Considerations of Equations for Estimating GFR

- Bias: average difference between estimated and measured values
- Precision: scatter of estimates around the measured value
- Accuracy: composite of bias and precision
- Reproducibility: within the same patient over time, intraassay, interlaboratory

Estimation of GFR

- Accuracy combines precision and bias.
- Achieving a high level of accuracy requires both low bias and high precision.
- Useful measure of accuracy: the percent of estimates by new method falling within 0.7~1.3 X or 0.5~1.5 X of the measured GFR

CKD Population With Decreased GFR



CKD Population With Decreased GFR

Table 2 Validation Studies of 4v-MDRD Equation in Large Series of CKD Populations (GFR <60 mL/min/1.73 m²)

	No. of Patients	Marker	GRF	Evaluation MDRD Equation		
			Mean (range), mL/min/1.73 m ²	Bias*	Precision†	P 30%‡
Rule et al ³¹ (2004)	320	Iothalamate	48 (5-133)	-6.2%	r ² = 0.79	75%
Poggio et al ³² (2005)	579 (non-diabetes)	¹²⁵ I-iothalamate	36 (10-81)	1%	r ² = 0.81	74%
	249 (diabetes)		24 (9-52)	-4%		63%
Cirillo et al ³³ (2005)	149	Inulin	<60	-3.1%	N/A	N/A
Froissart et al ³⁴ (2005)	1051	⁵¹ Cr-EDTA	<60	1.3 mL/min/1.73 m ²	8.5 mL/min/1.73 m ²	83%

GFR were measured by urinary clearance methods using (unlabeled) iothalamate, ¹²⁵I-iothalamate, inulin or ⁵¹Cr-EDTA.

*Bias is defined as the mean difference between estimated and measured GFR, as expressed in percentage or mL/min per 1.73 m².

†Precision is defined as either r² derived by linear regression or one SD of bias (mL/min per 1.73 m²).

‡P 30% is "accuracy within 30%" corresponding to the percentage of estimated values within a range of 70-130% of the measured GFR.

CKD Patients With Normal Baseline GFR or Hyperfiltration

Table 3 Validation Studies in Type-1 Diabetes Patients With Normal Baseline GFR or Hyperfiltration (GFR >140 mL/min per 1.73 m²)

	GFR (mL/min/1.73 m ²)	>> C-G eGFR >> (mL/min/1.73 m ²)	4v-MDRD eGFR (mL/min/1.73 m ²)
Vervoort ⁴⁶ (2002) (noncomplicated diabetes)	122 ± 18	119 ± 16	108 ± 18
Absolute difference (90th percentile)		23%	32%
Ibrahim ⁴⁷ (2005) (DCCT cohort)*	122 ± 23	116 ± 21	110 ± 19
Bias (mL/min/1.73 m ²)		-6	-22
Accuracy			
Within 10%		39%	25%
Within 30%		88%	78%

Type-2 Diabetes: Underestimating GFR decline

Table 4 Longitudinal Studies of Type-2 Diabetic Patient With Normal Baseline GFR and Hyperfiltration

Study/No. of Patients (Follow-up)	Baseline GFR (mL/min/1.73 m ²)			Rate of GFR Decline (mL/min/year)		
	Measured	C-G	4v-MDRD	Measured	C-G	4v-MDRD
Nielsen ⁴⁸ (1999)						
n = 36 (2.7-7.5 yrs)	104 ± 18 (⁵¹ Cr-EDTA)	82 ± 16	-	-1.5 ± 2.5	-2.8 ± 5.3	例外 -
Perkins ⁴⁹ (2005)						
n = 30 (m = 3.8 ± 0.3 yrs)	153 ± 27 (iothalamate)	-	130 ± 32	-4.4 ± 10.3%	-	-2.8 ± 10.3%
n = 10, stable function	148 ± 18	-	137 ± 21	2.9 ± 2.0%	-	-0.7 ± 7.1%
n = 20, declining function	156 ± 30	-	127 ± 35	-8.1 ± 10.9%	-	-4.4 ± 11.2%
Fontseré ⁵⁰ (2000)						
n = 87 (over 10 yrs)	>140 (¹²⁵ I-iothalamate)	-	-	-4.8 ± 4.7	-0.9 ± 1.4	-1.0 ± 2.5
	140-90	-	-	-3.0 ± 2.3	-1.2 ± 2.5	-0.7 ± 1.5
	30-89	-	-	-1.4 ± 1.8	-1.0 ± 0.9	-1.3 ± 1.4
Rossing ⁵¹ (2006)						
n = 156 (3-17 yrs)	117 ± 24 (⁵¹ Cr-EDTA)	103 ± 24	42 ± 20	-4.1 ± 4.2	-3.4 ± 3.2	-2.9 ± 2.8

Identifying the Early Stages of CKD for Kidney Transplant Donor

Table 5 Validation Studies in Kidney Transplant Donors

	No. of Patients	Marker	GFR	MDRD-eGFR	Evaluation MDRD eq.		
			Mean \pm SD (mL/min/1.73 m ²)	Mean \pm SD (mL/min/1.73 m ²)	Mean Bias (mL/min/1.73 m ²)	Precision (r ²)	P 30%
Rule et al ³¹ (2004)	580	Cold ioth.	101 \pm 17	72 \pm 11	-29	0.19	54%
Lin et al ⁵⁵ (2003)	117	¹²⁵ I-ioth.	103 \pm 16	95 \pm 25	-18.3	0.02	65%
Poggio et al ³² (2005)	457	¹²⁵ I-ioth.	106 \pm 18	97 \pm 21	-9.0 ^a	0.13	86%
Froissart et al ³⁴ (2005)	112	⁵¹ Cr-EDTA	≥ 90		-5.8 ^a	N/A	N/A
	50		60-89		+0.6 ^a	N/A	N/A

Abbreviations and definitions as in Table 2.

Patients with CKD and Normal Scr or at Higher Risk

Table 6 Validation Studies for the Diagnosis of Early Stages of CKD in Populations With Normal or Near-normal Scr

	Population	Clearance Method	GFR (mean [range]), mL/min/1.73 m ²		Bias (mL/min/1.73 m ²)	Precision (r ²)	Accuracy (30%)
Bostom ⁵⁷ (2002)	Known CKD and Scr	Pl.Cl _{iohexol}	(109 [18-205])	C-G	-26.5	0.17	59
n = 109	<1.5 mg/dL			4v-MDRD	-41.7	0.29	28
Verhave ⁵⁸ (2005)	CVD risk screening and	u.Cl _{99mTc-DTPA}	(99 [33-201])	C-G	-21 [*] /-5 [†]	0.32	71 [*] /87 [†]
n = 850	Scr <1.5 mg/dL			4v-MDRD	-29 [*] /-12 [†]	0.34	51 [*] /89 [†]
Smilde ⁵⁹ (2006)	CHF and syst.dysf.	u.Cl ¹²⁵ _{I-ioth.}	(73 [13-133])	C-G	-6	0.63	76
n = 234				4v-MDRD	-12	0.68	80

CVD, cardiovascular disease; CHF and syst.dysf., chronic heart failure with systolic dysfunction; Pl.Cl, plasma clearance; u.Cl, urinary clearance. Other abbreviations and definitions as in Table 2.

^{*}Jaffé reaction assay.

[†]Enzymatic assay for serum creatinine measurements.

MDRD公式之缺點

- Underestimate GFR decline over time in type-2 diabetes
- Underestimate GFR in patients with
 - (1) CKD stage 1 and 2
 - (2) Normal baseline GFR or hyperfiltration
 - (3) the early Stages of CKD for Kidney transplant donor
 - (4) lower BMI
- Best estimate GFR in patients with CKD stage 3
- Overestimate GFR in patients with
 - (1) CKD stage 4 and 5
 - (2) old Age: MDRD > C-G equation
 - (3) higher BMI: C-G equation > MDRD

腎絲球過濾速率之最佳實用估測法

- 成人用 **MDRD Study**及**Cockcroft-Gault** 公式
- The serum creatinine concentration alone should not be used to assess the level of kidney function.
- **Clinical laboratories should report an estimate of GFR** in addition to serum creatinine.
- Autoanalyzer manufacturers and laboratories should **calibrate** serum creatinine assays using an international standard.

收集24小時尿液計算肌酸酐廓清率

- **Not more precise** than the above-mentioned equations
- Providing **useful information** for individuals with
 - * exceptional **dietary intake**: vegetarian diet, creatine supplements
 - * exceptional **muscle mass**: amputation, malnutrition, muscle wasting
 - * assessment of **diet and nutritional status**
 - * need to start **dialysis**

Table 12 When Clearance Measurements May Be Necessary to Estimate GFR

- Extremes of age (elderly, children)
 - Extremes of body size (obesity, type 2 diabetes, low body mass index, ie, $<18.5 \text{ kg/m}^2$)
 - Severe malnutrition (cirrhosis, end-stage renal failure)
 - Grossly abnormal muscle mass (amputation, paralysis)
 - High or low intake of creatinine or creatine (vegetarian diet, dietary supplements)
 - Pregnancy
 - Rapidly changing kidney function
 - Prior to dosing (high toxicity drugs, excreted by the kidney)
 - Prior to kidney donation
-

Adapted from KDIGO recommendations.²

其他腎絲球過濾速率之估測法

- Capillary electrophoresis of non-radiolabeled iothalamate in blood and urine Wilson AJKD 30: 646-52, 1997
- **Cystatin C (serum level):** Coll et al. AJKD 36: 29–34, 2000
 - * endogenous protease inhibitor with **MW 13300**
 - * produced at a constant rate by all nucleated cells
 - * filtered across the glomerular membrane
 - * **catabolised** largely in the **proximal tubule**
 - * **neither secreted nor reabsorbed** along the nephron
 - * serum level unaffected by inflammation & malignancy
 - * detecting **subtle renal function decline** (GFR<88 ml/min)
 - * the **same reference values** for children and adults, not depending on sex, muscle mass, or age
 - * **1/[cystatin C] relates more closely to GFR** than CCr.

內容概要

- 個案介紹
- 慢性腎臟病的定義
- 腎臟功能評估的方法
- 慢性腎臟病的分期
- 慢性腎臟病的整體照護觀念

慢性腎臟病的分期

分期	描述	腎絲球過濾速率 GFR(ml/min/1.73 m ²)
1	腎臟受損合併正常或增加的腎絲球過濾速率	≥ 90
2	輕度腎絲球過濾速率下降	$90 > \text{GFR} \geq 60$
3	中度腎絲球過濾速率下降	$60 > \text{GFR} \geq 30$
4	重度腎絲球過濾速率下降	$30 > \text{GFR} \geq 15$
5	末期腎衰竭	< 15

- 慢性腎臟病: 定義為GFR小於60ml/min/1.73m²超過3個月
- 腎臟受損: 定義為有病理上的變化或血液尿液或影像學的異常

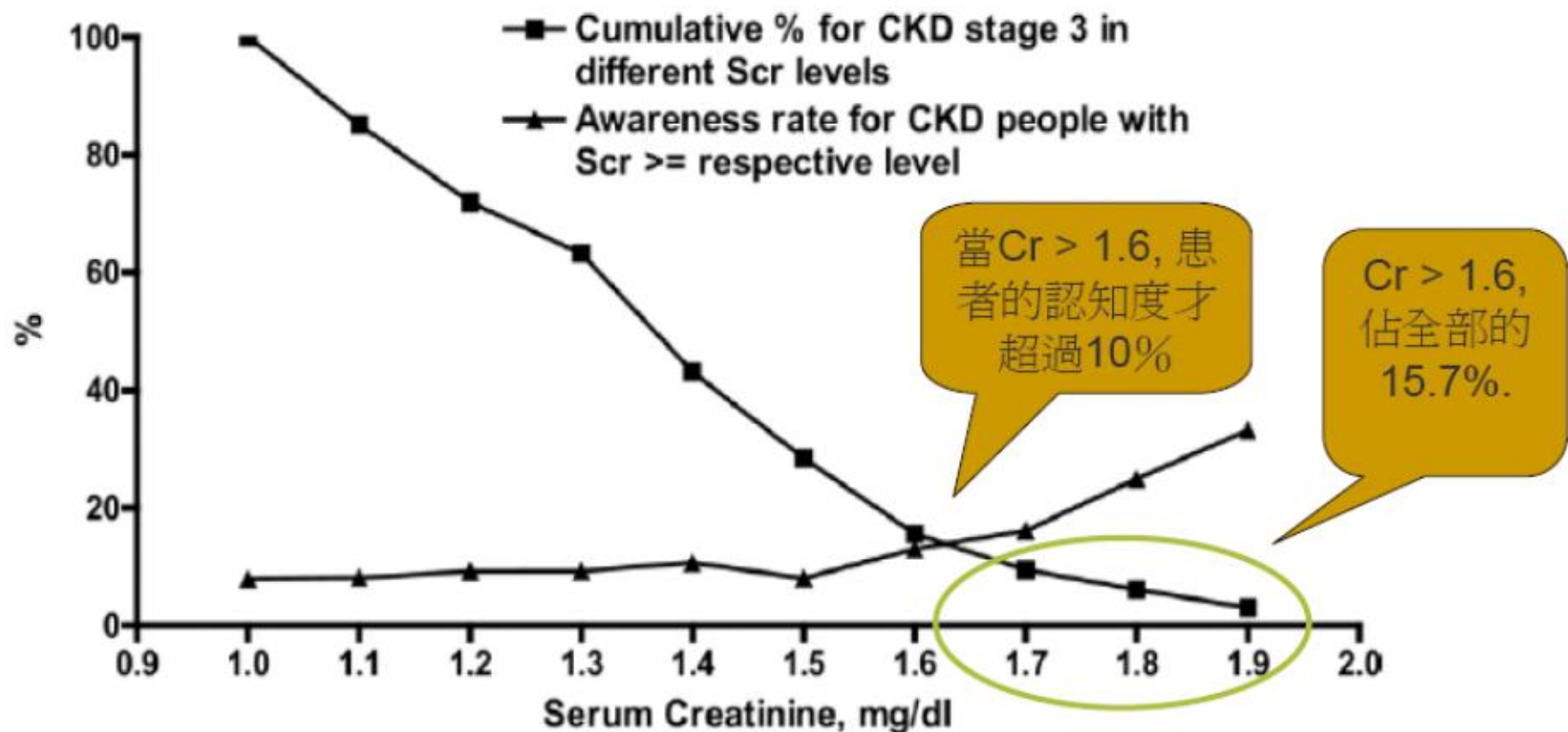
Table 13. Prevalence of GFR Categories: NHANES III 1988–1994 US Adults Age ≥ 20

GFR (mL/min/1.73 m²)	N*	Prevalence (95% CI)	Prevalence in Taiwan
≥ 90	10,183	64% (63–66)	1.02 %
60–89	4,404	31% (30–33)	3.79 %
30–59	961	4.3 % (3.8–4.7)	6.81 %
15–29	52	0.2% (0.1–0.3)	0.22 % (4) / 0.1% (5)

GFR estimated from serum creatinine using MDRD Study equation based on age, gender, race and calibration for serum creatinine.

* N is based on number of individuals in each listed GFR range in NHANES III, 1988–1994. Prevalence and number of individuals estimated by extrapolation to population of US adults age ≥ 20 (N = 177 million). Based on one-time assessment of estimated GFR.

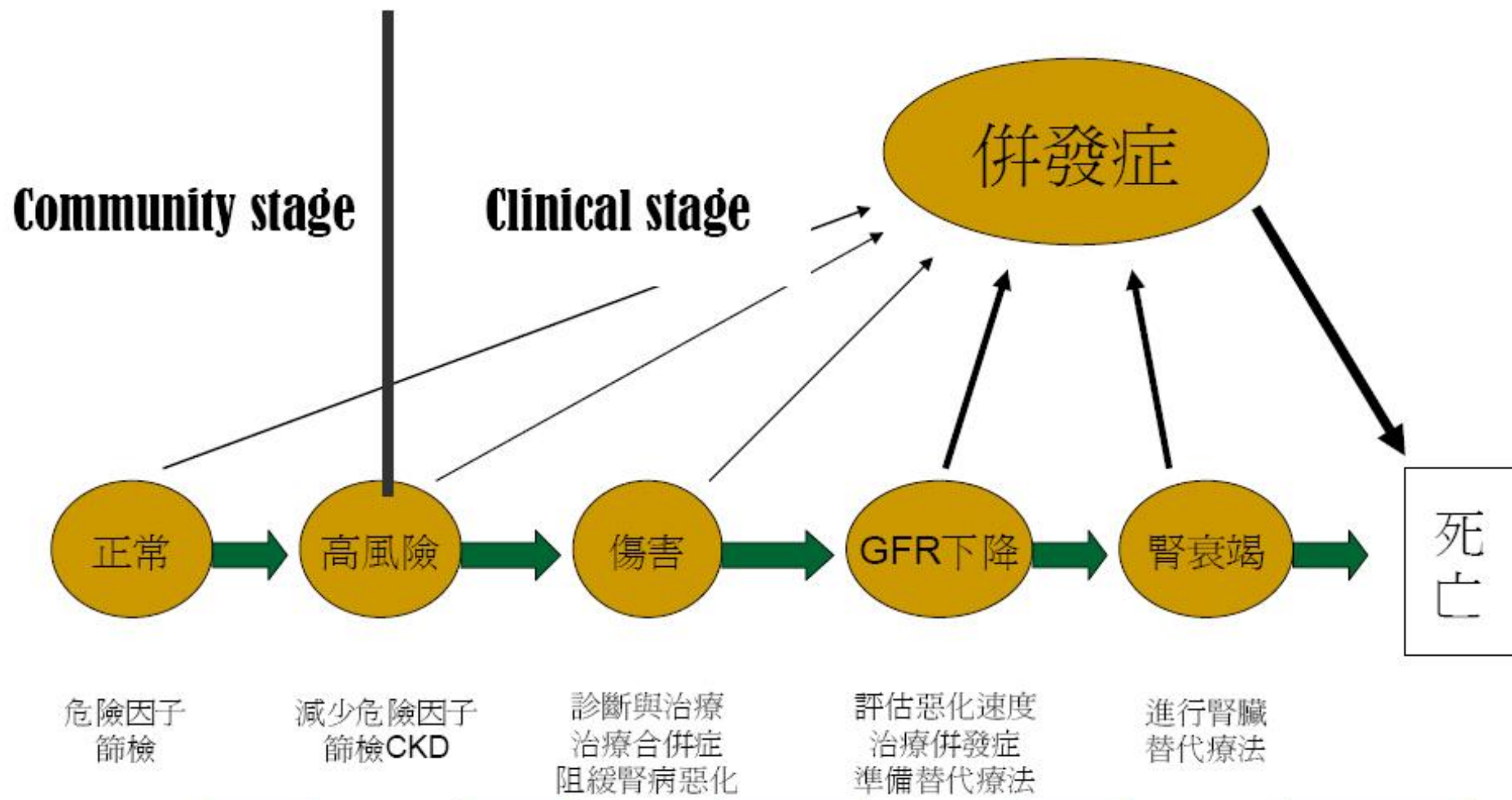
High Prevalence and Low Awareness of CKD in Taiwan



內容概要

- 個案介紹
- 慢性腎臟病的定義
- 腎臟功能評估的方法
- 慢性腎臟病的分期
- 慢性腎臟病的整體照護觀念

CKD自然病程與治療策略模式圖



慢性腎臟疾病的診斷步驟

● 病史詢問:

包括過去病史、家族病史、藥物史及職業史

● 身體檢查:

血壓、脈搏、肢體水腫、心肺及神經學檢查

● 實驗室檢查:

血液及尿液檢查

● 影像學檢查:

靜脈腎盂攝影 (IVP), 超音波(sono), 電腦斷層(CT), 磁共振造影(MRI), 血管攝影, 核子醫學攝影

● 腎臟切片

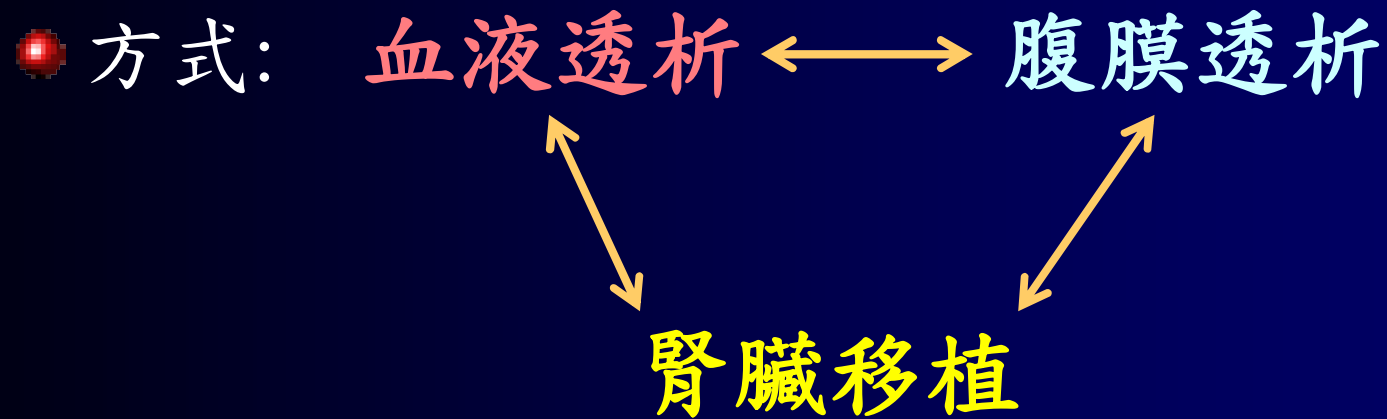
慢性腎臟疾病之病因分類

●糖尿病腎病變：第一型及第二型

●非糖尿病腎病變：

- 腎絲球疾病：自體免疫疾病，感染症，藥物，腫瘤
- 腎血管疾病：高血壓，抽煙，粥狀動脈硬化，血栓
- 腎小管間質疾病：尿路感染，結石，尿路阻塞，
藥物
- 囊腫性疾病：多囊腎，遺傳性腎囊腫疾病

腎臟替代療法 (Renal Replacement Therapy)



- 首先瞭解腎臟替代療法：
- 其次為腎臟替代療法預備：
- 最重要能有效治療

原發疾病

糖尿病, 高血壓

Underlying cause of CKD

(A) HbA1c < 7%

(B) BP < 125~130/75~80

(I) Immunosuppression

慢性腎臟病

腎絲球腎炎, 腎小管間質性腎炎, 多囊腎

Stages 1-2

Stages 3

Stages 4

Stage 5 before dialysis

末期腎病 接受透析 或 腎臟移植

Slow Δ GFR: ABCDPI

Cholesterol, Cigarette

Drugs (NSAID, Kremezin)

Proteinuria: ARB, anti-Plt

CKD care

Anemia: Hct/Fe

Bone: Ca/P

CVD: CAD/CHF/

Diet: nutrition/vit.

Electrolyte: Na/K

Fluid: BW

Gas: acidosis

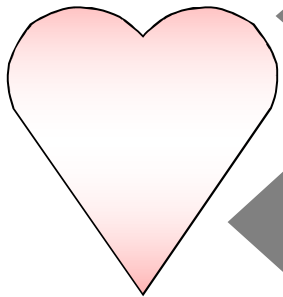
HR: arrhythmia

GI: GERD/DU/GU

Obstruction: BPH/
stone/ PAOD

U: uric acid

保護心臟



個案介紹

一位68歲女性, 主述於老人健檢發現BUN 19 mg/dl, Cr 1.4 mg/dl, FBS=108 mg/dl, 蛋白尿+, 並無臨床症狀, 診所醫師建議他到醫院檢查, 結果:

BP 150/90 mmHg, 體重42公斤, BUN 22 mg/dl, Cr 1.4 mg/dl, FBS=112 mg/dl, proteinuria (+), 尿酸 8.2 mg/dl, 膽固醇 248 mg/dl, TG 257 mg/dl. 接下來您應該

- (1) 安排那些進一步的檢查?
- (2) 建議如何治療?
- (3) 建議異常數值的控制目標為何?

Question

在診斷方面，您會再安排哪些檢查？

A. CBC

B. The value of HbA1C

C. Serum albumin level, Ca/P, Na/K, HCO_3^- , HDL, LDL

D. A 24 hr urine collection for protein, albumin, creatinine clearance (Ccr) or [spot urine Pt/Cr, albumin/Cr]

E. High – sensitivity CRP

F. 眼科會診

G. 2hr pc sugar

H. Ultrasonography of lower abdomen (kidneys & UB)

I. EKG, CXR \pm EF/wall motion, myocardial scintigraphy

J. Others ... such as Renal biopsy?

Laboratory Data

- A. CBC: Hb=9.2 g/dl, Hct=27.5%, ferritin=42.5 ng/ml , TSAT=15%
- B. HbA1C=7.8%, 2hr pc sugar =204 mg/dL
- C. Serum albumin=3.3 g/dl, Ca/P=9.2/4.7 mg/dl, Na/K=129/5.1 mEq/L, HCO_3^- =18.2 mEq/L, HDL=39 /LDL=154 mg/dL, PTH=32 pg/ml
- D. High – sensitivity CRP = 0.956 mg/dL (low risk <0.1<middle risk <0.3< high risk)
- E. Urinalysis: protein 3+, sugar +, WBC 21-35/HPF
- F. 24 hr urine protein 3.1 gm, albumin 1.8gm, **eCCr= 25.5 cc/min** (CKD stage 4?), **eGFR= 40 cc/min/1.73m²** (CKD stage 3), uric acid 850 mg, spot urine Pt/Cr=6.0, albumin/Cr=3.5
- G.眼科會診: proliferative diabetic retinopathy
- H. EKG: LVH, CXR: CT ratio =0.58 ; LVEF/RVEF=41%/43%; hypokinesia over lateral wall of LV, myocardial scintigraphy: perfusion defect over lateral wall of LV
- I. Ultrasonography: RK/LK=9.6/10.1cm, chronic renal parenchymal disease, thickening of the wall of urinary bladder
- J. ABI= 0.8 (Rt)/0.92 (Lt) ; Renal biopsy: not indicated

治療計畫

- CKD 的分期: CKD stage 3
- CKD 的原因
- 有哪些合併症？
 1. 會使腎功能惡化：高血壓，心衰竭，冠心症，貧血
 2. 可能和腎功能惡化無關的：
- 非藥物治療照護重點：飲食控制，運動，戒菸
- 治療的選擇與適當劑量（安全性與有效性）
- 病患的預後為何？會惡化到尿毒症嗎？約多久？

Question: 如何治療這位病患？

- Delay deterioration of renal function: ARB
- **Hypertension** management: **SBP/DBP <125~130/75~80** mmHg
- Diet control: on low fat/ low K^+ / low protein (0.8g/kg) DM diet
- Control of **hyperglycemia**: OAD or insulin to keep **HbA1c < 7%**
- Dx & Tx of **AKI**: overdiuresis, hypovolemia, nephrotoxin or BPH
- Treatment for **proteinuria**: ARB \pm antiplatelet (dipyridamole or pentoxifylline) \pm vitamin D₃
- Control of **hyperlipidemia**: **LDL < 70** mg/dl (CKD I-IV), **< 100** (V)
- Survey & prevention of **cardiovascular diseases**
- Control **anemia**: IV iron to keep **Hct 33~36%**, ferritin > 100 ng/ml, TSAT > 20% then add erythropoietic stimulating agent
- Control **acidosis**: NaHCO₃ 1-2 # tid to keep **[HCO₃] > 22** mEq/L
- Control **Phosphate** (**2.7 < P < 4.6** mg/dL), **Ca 8.5~9.5** mg/dL & **PTH (150~300** pg/ml) by phosphate binder, vitamin D₃, calcimimetics

CKD 各分期的治療策略

Stage	Description	GFR (ml/min/1.73 m ²) / (follow-up frequency)	Action
1	Kidney Damage with Normal or ↑ GFR	≥ 90 (6 months)	診斷及治療 治療合併症 延緩腎功能惡化 減少心血管疾病危機
2	Mild ↓ GFR	90 > GFR ≥ 60 (3-6 Mo)	預估腎功能衰退情形
3	Moderate ↓ GFR	60 > GFR ≥ 30 (2-3 Mo)	評估及治療併發症
4	Severe ↓ GFR	30 > GFR ≥ 15 (1-2 Mo)	準備腎臟替代療法
5	Kidney Failure	<15 (0.5-1 Mo)	尿毒症出現時 開始替代療法

桂林山水甲天下 台灣腎臟甲全球



by Chih-Ching Lin

感謝聆聽