

Measurement of TmP/GFR

Introduction

The ratio of tubular maximum reabsorption of phosphate (TmP) to GFR is used to evaluate renal phosphate transport. Renal tubular phosphate reabsorption is controlled by dietary phosphate, hormones (such as PTH, Vitamin D, FGF23) and metabolic factors (such as acid base disorders or ECF volume disturbance).

TmP/GFR

This essentially corresponds to the theoretical lower limit of serum phosphate below which all filtered phosphate would be reabsorbed.

Calculation of TmP/GFR assumes that serum phosphate concentration is equal to its concentration in the glomerular filtrate, and that creatinine clearance is a close approximation to GFR.

Fractional Tubular Reabsorption of Phosphate (TRP)

The fraction of phosphate in the glomerular filtrate that is reabsorbed in the renal tubules. If TRP is low in hypophosphataemia this usually points to a renal tubule defect.

Indications

It may be useful in assessing renal reabsorption of phosphate in a variety of pathological conditions associated with hypophosphatemia including:

1. Required (together with 1,25 hydroxy vitamin D) for diagnosis of:
 - X linked hypophosphataemic rickets
 - Autosomal dominant hereditary hypophosphataemic rickets
 - Oncogenic osteomalacia
2. Monitoring of the response to GH in X-linked hypophosphataemic rickets.
3. Autosomal recessive hereditary hypophosphataemic rickets with hypercalciuria.
(This is caused by a mutation in the sodium phosphate co-transporter 2c gene and is associated with normal vitamin D activation but ineffective transport in the tubules. There is a mild version with hypophosphataemia, nephrolithiasis and osteopenia which is associated with sodium phosphate co-transporter 2a mutations).
4. TmP/GFR may be of use in determining the amount of intra-cellular phosphate repletion required with persistently low phosphate. Acquired causes of hypophosphataemia include diuretic use, osmotic diuresis, chronic liver disease, sepsis, acidosis or due to steroid use.
5. Investigation of renal stone disease (in the absence of hyperparathyroidism) to exclude tubular defects.

It is no longer used in the investigation of disturbances of calcium homeostasis.

Procedure

1. Overnight fast
2. The first voided urine should be discarded.
3. Collect a 25 ml sample of the second void urine into a universal container for urine creatinine and phosphate
4. Send with serum electrolytes and phosphate.

**BLOOD SCIENCES
DEPARTMENT OF CLINICAL BIOCHEMISTRY**

Title of Document: Measurement of TMP/GFR
Q Pulse Reference N^o: BS/CB/DCB/PROTOCOLS/20
Authoriser: Peter Beresford

Version N^o: 5

Calculation

1. Calculate the ratio of phosphate clearance to creatinine clearance (C_P/C_{Cr})

$$C_P/C_{Cr} = \frac{\text{serum creatinine} \times \text{Urine phosphate}}{\text{Urine creatinine} \times \text{Serum phosphate}}$$

(This ratio is normally less than 0.15 and is often elevated in primary hyperparathyroidism).

2. Subtract this fraction from 1.0 to give the fractional tubular reabsorption of phosphate (TRP).

$$\text{TRP} = 1 - \frac{\text{serum creatinine} \times \text{Urine phosphate}}{\text{Urine creatinine} \times \text{Serum phosphate}}$$

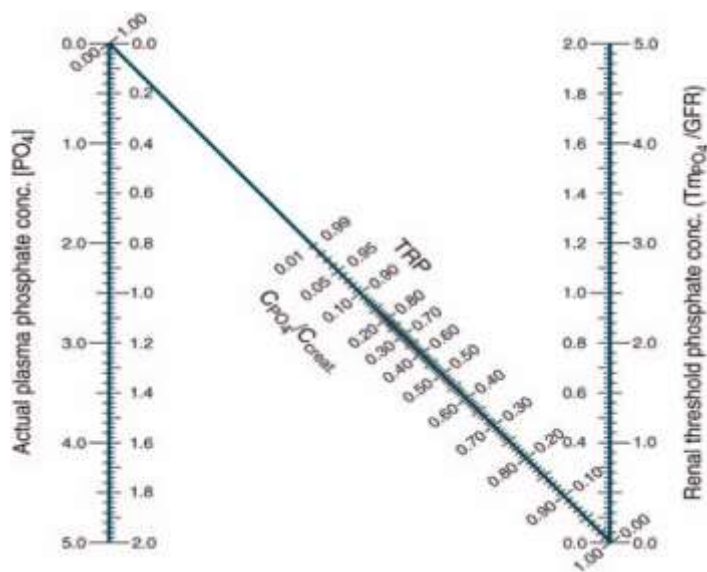
3. If TRP is ≤ 0.86 then phosphate reabsorption is maximal and there is a linear relationship between plasma phosphate concentration and excretion and TmP/GFR which is calculated by:

$$\text{TmP/GFR} = \text{TRP} \times \text{serum phosphate}$$

4. If TRP is > 0.86 relationship between plasma phosphate concentration and excretion is curvilinear and TmP/GFR is defined as follows:

$$\text{TmP/GFR} = \alpha \times \text{serum phosphate}, \text{ where } \alpha = \frac{0.3 \times \text{TRP}}{1 - (0.8 \times \text{TRP})}$$

Alternatively, TmP/GFR can also be determined using a nomogram after measuring fasting plasma and urine concentrations of phosphate and creatinine.



Nomogram to determine tubular maximum reabsorption rate of phosphate to glomerular filtration rate (TmP/GFR) given plasma phosphate (PO₄) concentration and tubular reabsorption of phosphate (TRP). On the vertical axes, the inner scale is in mmol/L, whereas

**BLOOD SCIENCES
DEPARTMENT OF CLINICAL BIOCHEMISTRY**

Title of Document: Measurement of TMP/GFR
Q Pulse Reference N^o: BS/CB/DCB/PROTOCOLS/20
Authoriser: Peter Beresford

Version N^o: 5

the outer scale is in mg/100 mL. TRP is calculated as detailed in text. A straight line joining plasma phosphate concentration, TRP and the right vertical axis gives the TmP/GFR.

Interpretation

Low levels suggest renal phosphate wasting.

Age-related reference ranges for TmP/GFR are given below (taken from reference).

Adults

Age	Male Range (mmol/L)	n	Female range (mmol/L)	n
25-35 years	1.00-1.35	15	0.96-1.44	15
45-55 years	0.90-1.35	15	0.88-1.42*	15
65-75 years	0.80-1.35	15	0.80-1.35	15

*Premenopausal

Paediatric Ranges

Age	Range (mmol/L)	n
Birth	1.43-3.43	20
3 months	1.48-3.30	20
6 months	1.15-2.60	20
2-15 years	1.15-2.44	101

References

1. Phosphate homeostasis and disorders. P. Manghat. Ann Clin Biochem. 2014
2. Renal Tubular reabsorption of phosphate, (TmP/GFR): indications and interpretation. Payne RB Ann. Clin. Biochem. 1998; **35**: 201-206.

**BLOOD SCIENCES
DEPARTMENT OF CLINICAL BIOCHEMISTRY**

Title of Document: Measurement of TMP/GFR
 Q Pulse Reference N^o: BS/CB/DCB/PROTOCOLS/20
 Authoriser: Peter Beresford

Version N^o: 5

Appendix 1: Worksheet

Measurement of TMP/GFR (tubular maximum phosphate reabsorption)

Patient attends day case unit after an overnight fast (fluids only)

On arrival, send **spot** urine sample (**plain** container) for electrolytes and phosphate (requires a paper request form because can't request spot urine phosphate in ICE) AND a blood sample for R3

NB IF THE PATIENT HAS ALSO BROUGHT IN A 24H URINE SAMPLE, ENSURE THAT THIS IS SENT OFF FOR THE TESTS SPECIFIED IN CLINIC, **NOT** FOR PHOSPHATE OR ELECTROLYTES

Worksheet for calculating results

DATE:.....

Serum creatinine:.....umol/L Urine phosphate.....mmol/L

Serum phosphate.....mmol/L Urine creatinine.....umol/L

$FEPO_4 = \frac{\{\text{serum creatinine}\} \times \{\text{urine phosphate}\}}{\{\text{serum phosphate}\} \times \{\text{urine creatinine}\}}$

=

Fractional tubular reabsorption of phosphate, TRP = 1 – FEPO₄ =

=

If TRP < 0.86, T_mP/GFR = TRP x Serum phosphate

IF TRP > 0.86, T_mP/GFR = {0.3 x TRP/[1 – (0.8 x TRP)]} x plasma phosphate

T_mP/GFR =

**BLOOD SCIENCES
DEPARTMENT OF CLINICAL BIOCHEMISTRY**

Title of Document: Measurement of TMP/GFR
Q Pulse Reference N^o: BS/CB/DCB/PROTOCOLS/20
Authoriser: Peter Beresford

Version N^o: 5

Interpretation:

See protocol for reference ranges. Low values indicate PO₄ wasting