Management of Patients With Solitary or single Kidney for primary care clinician

Dr. Maryam Ghorbani

- How do primary care clinician diagnose a solitary kidney?
- What is a solitary kidney?
- What causes a solitary kidney?
- What are the complications of a solitary kidney?
- What are the symptoms of a solitary kidney?
- How do primary care clinician diagnose a solitary kidney?
- How do primary care clinician treat a solitary kidney?
- Can I prevent injury to my solitary kidney?

How do health care professionals diagnose a solitary kidney?

- Incidentally in abdominal ultrasound
- Secondary hypertension survey
- Post unilateral nephrectomy_for living kidney donation, renal malignancy or trauma
- CKD patient

What is a solitary kidney?

- Solitary kidney is a condition in which a person has a single kidney instead of two kidneys.

- A person may be born with one kidney (renal agenesis), have two kidneys but only one functional (renal dysplasia) or Post unilateral nephrectomy for living kidney donation, renal malignancy or trauma.

What causes a solitary kidney?

- The three main causes of a solitary kidney are:
- Birth defects
- ✓ Renal agenesis, renal dysplasia

- Surgical removal of a kidney
- ✓ Post unilateral nephrectomy for staghorn stone, renal malignancy or trauma

- Kidney donation
- ✓ A growing number of people are donating a kidney to be transplanted into a family member or friend whose kidneys have failed.

What are the complications of a solitary kidney?

- Complications from a solitary kidney are rare but may include;
- ✓ proteinurea
- ✓ Decreased GFR
- ✓ CKD or ESRD
- ✓ HTN
- ✓ High blood pressure or preeclampsia during pregnancy

What are the symptoms of solitary kidney?

- In general, people born with kidney agenesis or kidney dysplasia show no symptoms, lead full healthy lives, and may never discover they have a solitary kidney.
- Some people discover they have a solitary kidney by chance after having an x-ray, an ultrasound, or surgery for an unrelated condition or injury.
- A minority of people develop progressive loss of kidney function, and they can develop symptoms associated with CKD.

Pathophysiological Changes in Patients With a Solitary Kidney

Consequence of Acquired Solitary Kidney After nephrectomy for living kidney donation

- GFR is correlated with the number of nephrons, and it may vary by age, gender, and body habitus.

- Loss of nephrons is usually not a cause of decreased GFR, owing to compensatory mechanisms, although these do not provide full compensation and GFR increases to 65%–70% of pre-donation GFR in healthy donors aged <60 years.

- Whereas in the past, nephrectomy for living kidney donation was considered to be safe without a higher likelihood of CKD , more recent data suggest that there is a 3–5 times higher relative risk of ESRD after a unilateral nephrectomy.

- Since the excretory function of kidney is needed to maintain fluid, electrolyte, and mineral balances, physiological adaptation occurs immediately after nephrectomy.

- In addition to renal hemodynamic change after nephrectomy, structural nephron alteration in the form of both hypertrophy and hyperplasia may occur.

- However, this compensatory mechanism post nephrectomy in living kidney donor differs from patients after nephrectomy from other reasons.

- The compensatory glomerular hyperfiltration can cause damage to the solitary kidney in the long term, especially if there are other factors that would aggravate glomerular hyperfiltration, such as high dietary protein or high dietary sodium intake.

- Intraglomerular hypertension causes

1. proteinuria
2. glomerulosclerosis.

- These ultimately lead to pathological changes similar to those seen in FSGS and albuminuria, a decline in GFR, and CKD progression.

- In patients with solitary kidney, either congenital or acquired, compensatory mechanisms come into play to maintain renal function, such as glomerular hyperfiltration and hypertrophy and renin-angiotensin-aldosterone system activation.

- Glomerulonephritis appears to be the most common renal disease, leading to early ESRD in living kidney donors, and underlying genetic predispositions may contribute to faster progression of CKD to ESRD in some groups of living kidney donors.

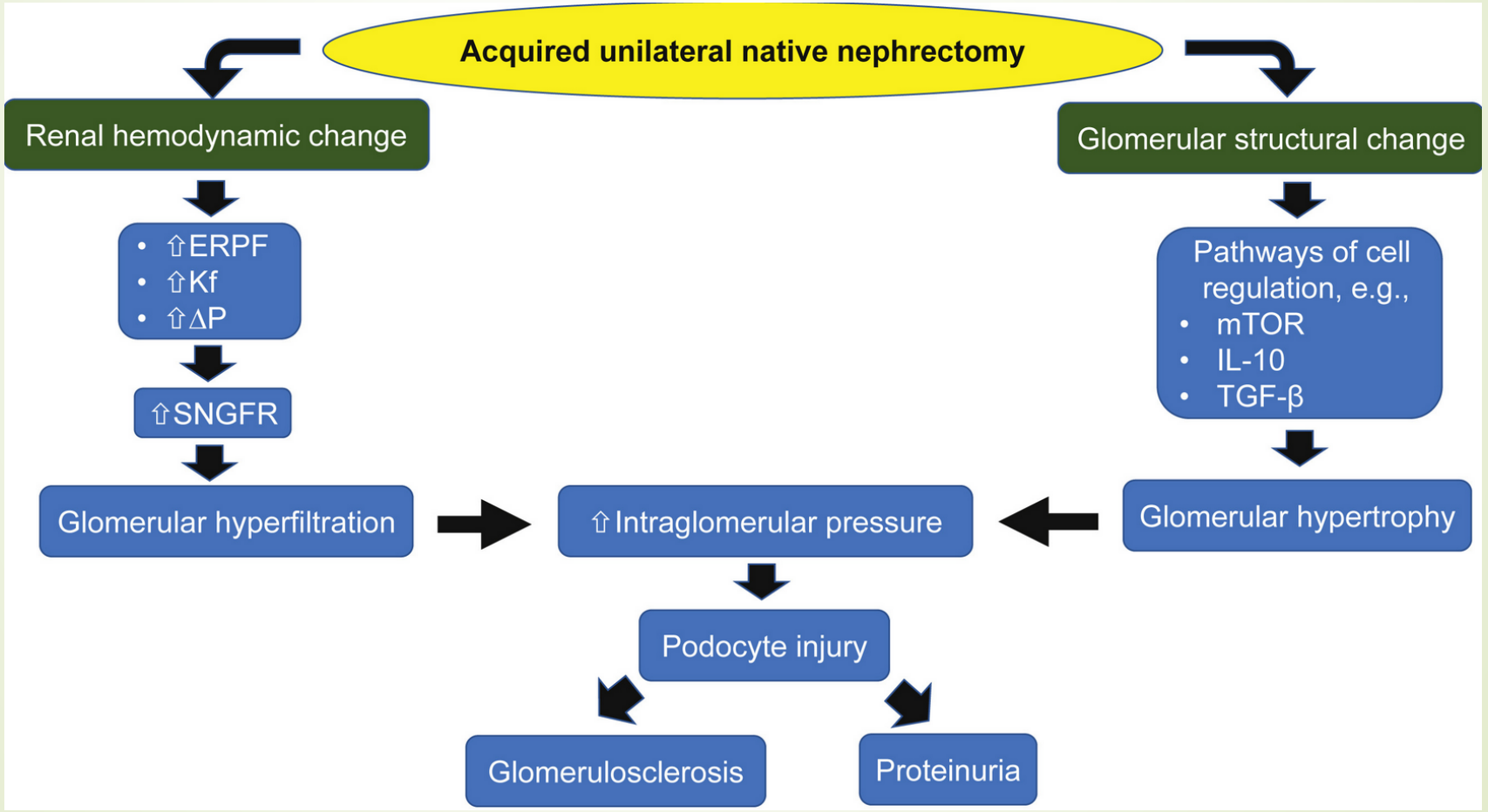
- Common causes of advanced CKD and ESRD in living kidney donors include diabetes mellitus, hypertension, and glomerulonephritis and are similar to those in the non-nephrectomized population; however, the time of ESRD onset may be different.

- Given that history of low birth weight, age, and gender are associated with nephron number, information on these factors may be useful when evaluating potential living kidney donors, informing renal prognosis after living kidney donation, and appropriately selecting potential living kidney donors to match recipient demand.

- Unilateral nephrectomy due to renal trauma and from living kidney donation is common in young and middle-aged persons, respectively

- whereas kidney malignancies are more common in older age groups, who are more likely to have underlying comorbidities, which increases the risk of CKD.

Pathophysiological changes after unilateral native nephrectomy.



- According to the conventional definition and staging of CKD, persons with only one kidney from congenital or acquired causes, such as donor nephrectomy, are classified as CKD patients, even if GFR is normal without albuminuria (<30 mg/g of creatinine).

- Therefore, initial screening for signs of worsening renal function and accurately determining renal function are warranted.

.

How do primary care clinician treat a solitary kidney?

- To prevent CKD or slow progression of a pre-existing CKD in a person with a solitary kidney, nonpharmacologic interventions should be utilized, although concurrent pharmacologic interventions may be used in selected patients.

- If you have a solitary kidney, your health care professional will monitor your kidney function by conducting urine and, sometimes, blood tests monitor and control your blood pressure

How do health care professionals treat a solitary kidney?

- health care professional uses two types of tests to monitor your kidney function
- ✓ GFRwith serumCr
- ✓ Proteinurea with U/A

- In some cases, your health care professional may perform additional tests to measure your kidney function.

Nonpharmacologic Interventions

1. Low-Protein Diet
2. Low Dietary Sodium Intake
3. Weight Control
4. Adequate Hydration
5. Smoking Cessation
6. Physical Activity After Nephrectomy

Low-Protein Diet

- Evidence suggests that high dietary protein intake is associated with higher risk for CKD or faster CKD progression, because it leads to afferent arteriolar vasodilatation which in turn increases intraglomerular pressure.

- Whereas a high-protein diet leads to an initial increase in GFR, in the long-term, increased intraglomerular pressure can lead to glomerular hyperfiltration and loss of kidney function.

- Several experimental studies and clinical trials demonstrated a beneficial effect of low dietary protein intake on slowing CKD progression, whereas a high protein intake increases risk of renal failure.

- Moreover, there is evidence of a linear relationship between the amount of protein intake and a decrease in eGFR.

- The quality of the protein may also play a role.

- Several epidemiologic studies reveal the benefit of plant-based proteins over an animal-based diet.

- The diet should include adequate fiber from plant-based sources, as does the Dietary Approaches to Stop Hypertension (DASH) diet and other diets and the amount of daily protein should be adjusted by level of renal function and proteinuria.

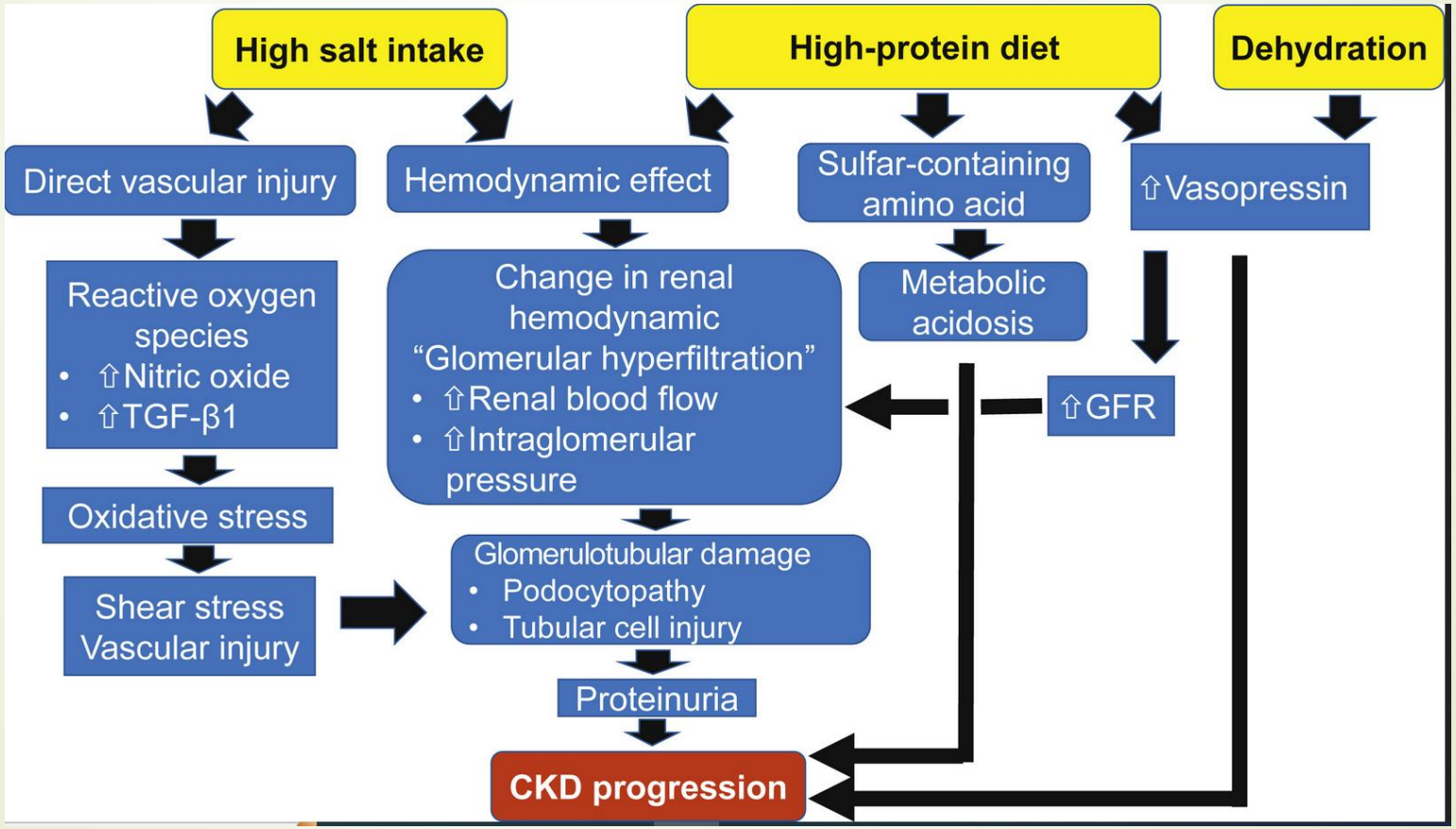
- It is often recommended that patients with hypertension follow an energy-controlled DASH diet, which is high in complex carbohydrates including fruits, vegetables, and whole grains, as well as legumes, and low in animal-based protein such as meat, saturated fat, refined grains, sweets, and processed food.

- These dietary strategies may help with weight maintenance or reduction in weight gain in obesity.

- However, we believe that it is wise to avoid a high protein intake of greater than 1 g/kg per day, except in the case of professional athletes or bodybuilders with well thought-out calculations on the needed protein amounts for anabolic goals.

- Currently, there are no data to corroborate these suggestions.

Mechanism of renal injury from high-protein diet, high salt intake, and dehydration



Low Dietary Sodium Intake

- High sodium intake can cause direct vascular injury even without hypertension and indirect renal damage from hemodynamic mechanisms mediated by elevated BP and proteinuria.

- similar to a high-protein diet, a high-sodium diet leads to increased intraglomerular pressure, causing glomerular hyperfiltration and subsequently renal injury .

- Incrementally worse cardiovascular outcomes were observed when dietary sodium intake exceeded 4 g/day.

- However, recent observations in the general population suggest that there is a J-shaped association in which both higher and lower dietary sodium intake (>5 and <3 g/d) were associated with higher risk of CVD and death.

- We recommend avoiding a diet with >4 g/d of sodium in individuals at higher risk of developing future CKD, including those with a solitary kidney.

Weight Control

- Even in living kidney donors who are determined to be healthy individuals, obese donors had a 1.86 times higher risk of ESRD over 20 years following nephrectomy compared to nonobese donors, and overweight donors exhibited incrementally a 7% higher risk of ESRD for every 1 kg/m^2 higher body mass index above 27 kg/m^2.

- Hence, any unintentional edema-free weight loss warrants timely work-up, and dietary interventions may be considered in those with more advanced CKD.

- We recommend a target body mass index of <30 kg/m^2 in non-athletes and non–bodybuilders with a solitary kidney.

Adequate Hydration

- Both animal and human studies demonstrate the inverse relationship between fluid intake and the long-term trajectory of GFR and risk of proteinuria.
- The mechanism of an increased GFR with low fluid intake may be related to increased secretion of vasopressin.
- We suggest adequate to generous fluid intake (>2.5 L/day) in persons with a solitary kidney and eGFR >60 ml/min per 1.73 m^2, as long as there is no material risk of hyponatremia.

Smoking Cessation

- Smoking is a known risk for many pathologies including CKD, based on some but not all studies, and may worsen CKD progression.
- The risk is attenuated but still as high as 45% in former smokers.
- Smoking cessation may slow the rate of renal function deterioration in CKD patients.
- Persons with solitary kidney should be advised routinely to avoid smoking.

Physical Activity

- Evidence showed that exercise improves some side effects for cancer, quality of life, and survival, via alteration in neuro-hormones.
- Trinh *et al.*[63] reported an association between physical activity and quality of life in kidney cancer survivor.
- For living kidney donors, physical activity improves not only their health and weight control, but also their mental health.

Pharmacologic Interventions

1. Blood Pressure Control
2. Proteinuria Management
3. Antiplatelet Agents

Blood Pressure Control

- Hypertension is an independent risk factor for progression of renal disease in people born with a solitary kidney.
- Early detection, regular follow up and prompt management of blood pressure may help slow the progression of renal function impairment.
- It has been reported that 47% of people with unilateral renal agenesis end up developing hypertension.
- Optimal blood pressure control and regular follow up of his renal function may help to slow the progression of renal disease.

Monitoring and controlling blood pressure

- **Monitoring and controlling your blood pressure is particularly important if you have a solitary kidney.**
- High blood pressure can damage blood vessels in your solitary kidney.
- If your health care professional diagnoses you with high blood pressure, he or she may prescribe one or more blood pressure-lowering medicines.
- Medicines that lower blood pressure can also significantly slow the progression of kidney disease.
- Two types of blood pressure-lowering medicines, **ACE and ARB**, may be effective in slowing your kidney disease progression while also lowering your blood pressure.
- A health care professional may also prescribe a **diuretics.**

- The level of BP by 24-hour BP monitoring, and the circulating renin–angiotensin system, including plasma renin activity and angiotensin II levels, are not altered.

- In living kidney donors, BP does not appear to be elevated in the short term, and similar data are reported in long-term follow-up studies (up to 5 years) and even in donors with pre-donation hypertension.

- Target BP of <130/80 mm Hg, and a BP threshold to initiate antihypertensive therapy of ≥140/90 mm Hg, are recommended for patients with no clinical CVD and a 10-year atherosclerotic cardiovascular disease risk of <10%; for patients with the latter risk of ≥10%, antihypertensive medications should be initiated when BP ≥ 130/80 mm Hg.

- Until there is strong evidence demonstrating that outcomes of living kidney donors are related to BP, individualized BP control appears to be appropriate.

Albuminuria Measurement

- In the setting of postnephrectomy for living kidney donation or any other reason, proteinuria may emerge and worsen over time.

- The 2017 Kidney Disease Improving Global Outcomes guidelines recommend checking assessment and monitoring of albuminuria in living kidney donors at least once a year for early detection of proteinuria

- Angiotensin pathway modulators including angiotensin converting–enzyme inhibitors and angiotensin receptor blockers are often used to improve proteinuria and slow progression of renal disease.

- Renin–angiotensin system blockade provides renoprotective and antiproteinuric effects in solitary kidney.

- As with a low-protein and low-sodium diet, decreased intraglomerular pressure will mitigate glomerular hyperfiltration and may slow progression of renal function decline.

Antiplatelet Agents

- Evidence suggests that aspirin lowers cardiovascular events in CKD and it may also delay CKD progression.
- As with the general population, CVD is an important cause of morbidity in living kidney donors.
- An epidemiologic study showed that compared with nonregular aspirin users, CKD patients using aspirin regularly had an 0.80 ml/min per 1.73 m^2/yr (95% confidence interval 0.1, 1.5) slower decline in GFR.
- We currently have no recommendation for or against intake of aspirin or other antiplatelet agents in persons with an acquired solitary kidney.

Evaluation and Follow-up for Renal Function in Solitary Kidney

GFR Estimation and Monitoring

- Several equations have been developed to estimate GFR.
- An "estimated" GFR (eGFR), be it based on serum Cr or cystatin C, is not an accurate method for assessing true GFR and may lead to inaccuracies.
- The KDIGO Clinical Practice Guideline for the Evaluation and Management of CKD recommend that an initial assessment for kidney function be conducted using serum creatinine and the eGFR equation, and that additional tests, e.g., serum cystatin C or a clearance measurement, be used as confirmatory tests when eGFR based on serum creatinine is less accurate.
- A major limitation of the creatinine-based GFR equations is related to creatinine production, renal creatinine secretion, extrarenal creatinine excretion, and technical issues pertaining to creatinine measurement.

GFR	Clinical use	Limitations	Clinical utilities for patients with a solitary kidney
ockcroft-Gault equation	When serum creatinine is stable; drug dosing[a]	Determined by muscle mass in steady state - Age - Gender - Race 10%–40% overestimate creatinine clearance Estimate creatinine clearance, not GFR Imprecise in CKD	Follow-up for stable renal function
MDRD Study equation	Accurately estimate[77] eGFR <60 ml/min per 1.73 m^2; accurate in nonhospitalized CKD	Not precise when eGFR >60 ml/min per 1.73 m^2 Leading to overestimate CKD prevalence Require steady state or stable renal	Follow-up for stable renal function

CKD-EPI equation	Can be used to estimate eGFRs >60 ml/min per 1.73 m^2 Compared to MDRD equation, CKD-EPI is better for higher levels of GFR, diabetes, transplant status, elderly, and at higher body mass index	Precision remains depending on creatinine measurement	Renal cell carcinoma with comorbidity, e.g., elderly, diabetes, obesity Living kidney donor whose renal functions are generally normal

- As discussed above, persons with a solitary kidney often develop glomerular hyperfiltration after nephrectomy, which occurs as early as the first week postoperatively and can continue for longer than 10 years.

- Tan *et al.* reported that the Modification of Diet in Renal Disease and the Chronic Kidney Disease Epidemiology Collaboration GFR estimating equations underestimated GFR, especially in living kidney donors ≥55 years old.

- A measured GFR can be performed by 24-hour urine collections or by assessing filtration markers that can be either endogenous or exogenous.
- A 24-hour urine test for creatinine clearance is a classic approach; however, it is inconvenient and can overestimate the true GFR due to renal tubular creatinine secretion.

Summery

1. avoidance of excessively high dietary protein intake (>1 g/kg per day) and high dietary sodium intake (>4 grams/d),
2. adequate dietary fiber intake from plant-based foods,
3. a target body mass index of <30 kg/m^2 (in non-athletes and non-bodybuilders),
4. and judicious management of risk factors of progressive chronic kidney disease (CKD),

- Dietary interventions to slow a decline in kidney function include low protein intake of <0.8 g/kg/day and low sodium consumption of 2–4 g/day as well as certain health dietary patterns.

- Plant Dominant (PLADO) diets, Dietary Approaches to Stop Hypertension (DASH), Mediterranean, and vegetarian diets may be favorable for living kidney donors with solitary kidney but the evidence is still lacking.

- **Thank you for attention**