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A Review on Kidney Targeted Drug Delivery Systems for Hydronephrosis

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Abstract: *Kidney-targeted drug delivery systems represent a promising approach for the effective management of hydronephrosis by ensuring therapeutic agents.directly to the affected renal tissues these systems minimize systemic side effects , enhance drug bioavailability, and improve treatment outcomes compared to conventional therapies.Kidney -targeted drug delivery systems hold great potencial to revolutionize the treatment of hydronephrosis and other renal disorders.Further investigations with suitable imaging are often required before an appopriate management plan can be defined.its hold great potential for improving the treatment of hydronephrosis. By delivering agents directly to the kidneys, these systems can enhance efficacy, reduce systemic side effects,and potentially mitigate kidney damage.Targeting anti inflammatory and anti-fibrotic drugs to proximal tubular cells may prevent systemic infection and renal tubular inflammation*

Innovation:- *Hydronephrosis is characterized by swelling of the kidney due to obstruction of urine flow. Traditional treatments mainly address the obstruction (e.g., surgery, stenting), while drug-based therapy often suffers from poor kidney specificity and systemic side effects. Innovative kidney-targeted drug delivery systems (KTDDS) aim to deliver therapeutic agents directly to renal tissues, improving efficacy while reducing toxicity*

Keywords*:* Kidney, Hydronephrosis

I. INTRODUCTION

1.1. What is kidney targeted drug delivery system ?

The kidney is a key organ serving several essential function. It is responsible for the formation of urine and performs a homeostatic function in maintaining acid-base balance and regulating electrolytes and water to maintain blood pressure.The kidney is a vital organ that filters blood and removes excess fluid and waste products Dysfunction of the kidney may break the fluid and electrolyte balance ,and lead to severe problems such infections of the urinary tract, inflammation and hypertension. Renal disease and systemic disease caused by renal disease occur throughout the world and are generally difficult to treat.(1)

1.2. Hydronephrosis:

hydronephrosis is unilateral or bilateral urine-filled aseptic dilation of the renal pelvis and calyces. When combined with dilation of the ureters, it is known as hydroureteronephrosis. Imaging modalities for the detection of hydronephrosis include computed tomography, intravenous urography and ultrasound.Hydronephrosis may be identified incidentally through imaging requested to investigate a non-related intra-abdominal symptom or in a symptomatic patient with loin pain and a rising creatinine level.(2)

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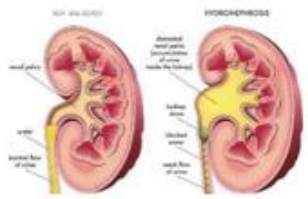

Figure no:-1Hydronephrosis (3)

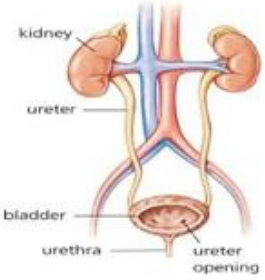

Figure no:-2 Urinary blokage(4)

Figure no:-3 Urine flow(5)

1.3. Kidney structure:- In the investigation of kidneys, renal imaging is the traditional approach. It demonstrates size, thickness, and presentation of parenchyma in the kidneys (echogenicity, corticomedullary distinction, identify focal lesions such as cancers, renal stones and cysts), hydronephrosis severity, ureteral dilation, and anatomy of the bladder (6)

1.4. Arterial Supply:- A good drainage on diuretic renogram, starting even before frusemide was graded as 0, whereas good drainage starting only after frusemide graded as 1, delayed equiv ocal drainage after frusemide as 2, poor response to fru semide with a plateau (and partial clearance in 2-h delayed image) as 3, and an up-rising curve with no response to frusemide (and stasis in 2-h delayed film) as 4. Ultrasono gram was graded according to SFU grading of 0e4 reported earlier.(7) • At 90 degrees to the arcuate arteries, the interlobular arteries arise.• The interlobular arteries pass through the cortex, dividing one last time to form afferent arterioles. • The afferent arterioles form a capillary network, the glomerulus, where filtration takes place. The capillaries come together to form the efferent arterioles. In the outer two-thirds of the renal cortex, the efferent arterioles form what is a known as a peritubular network, supplying the nephron tubules with oxygen and nutrients. The inner third of the cortex and the medulla are supplied by long, straight arteries called vasa recta.(8)

II. CAUSES OF HYDRONEPHROSIS

Obstructing ureteric stone, Pregnancy, Bladder lesion ,Kidney stone,Nerve or muscle problem,A blockage in the flow of pee at some point in their urinary tract,Narrowing of your urinary tract.(9)

III. SYMPTOMS OF HYDRONEPHROSIS

Sudden or intense pain in your sides, abdomen or back,Nausea or vomiting, Painful urination,Blood in your pee,Urinary tract infection [UTI],Being unable to completely empty your bladder, peeing more or less than normal.(10)

IV. HOW TO RESTORE NORMAL URINE FLOW AND PREVENT KIDNEY DAMAGE

4.1. Anotomical factor:- Comprehensive pregnancy anatomical and histological investigations of the ureters during have been carried out and generally a varying grade of hyperplasia periureteral connective tissue, hypertrophy of the ureteral of the smooth muscle, oedema and increased tract during external vascularity pregnancy. longitudinal were found; the same picture was shown by the genital The most prominent muscle layer surrounding suggested that this hypestrophy aspect was the hypertrophy of the the distal part of the ureter. It was could result in stricture, the dilatation. which would then explain If this is the case, however, then the dilatation just would have to begin above the urinary bladder and not first at a level with the linea terminalis,.(11)

4.2. Medical devices:- Catheter:- Individual with overflow incontinence may need to use a catheter to empty their bladder .your health care professional will teach you how to use a catheter. Proper hygiene is important for catheter use and to avoid a bladder infection,Pessary:- women may use a soft,plastic device called a pessary ,which is inserted into the vagina for stress incontinence. The pessary presses againt the wall of your vagina and the nearby urethra.The pressure helps hold up the urethra,so you have less leaking. Another newer product to treat stress incontinence is a

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tampon-like disposable device that you can insert into your vagina for up to 12 hours at a time.The product expands to push up against your urethra to help decrese leaks.(12)DJ stenting:-A double –dj stent is a temporary, flexible,J-shaped tube inserted into the ureter, tube that carries urine from the kidney to the bladder. Helping to normal urine flow in kidney and prevent from kidney damage.Hemodialysis:-A machine filters wastes,salts and fluid from your blood when your kidneys are no longer healthy enough to do this work adequately. Hemodialysis is generally not a painful procedure itself's though some patients experience discomfort or slight pain when needles are inserted into the access site.Needle Insertion:-you may feel a brief, sharp pinch or discomfort when the needles are placed in your arm to create a connection to the dialysis machine.(13)

V. DIAGNOSIS OF HYDRONEPHROSIS

5.1. Physical Examination:-Your provider will ask you about any symptoms your having and examine the area near your kidneys and bladder for tenderness or swelling.They may ask about your medical history and your family's medical history.People with a penis may need a rectal exam to determine whether their prostate is enlarged.People with a vagina might require a Pelvic exam to evaluate whether there are any problems with their uterus or ovaries,Urine Tests:-Your healthcare provider will collect a sample of your pee and analyse it for blood,stone crystals, bacteria or infection.They may need to use a catheter to drain the pee,Blood Tests:-A complete blood count (CBC) may determine whethere an infection is present.(14) Tests of kidney function, including creatinine, estimated GFR(eGFR) and blood urea nitrogen (BUN),may also occur,Imaging procedures:-The main imaging test is ultrasound. A CT SCAN or MRI may be necessary. A healthcare provider can detect hydronephrosis in a fetus as early as the first trimester on an ultrasound. It's typically discovered during a 20 –week ultrasound. A diagnosis at this this time usually means the birth mother needs additional ultrasounds to monitor the fetus.however, most cases resolve on their own, Flank pain is the main symptom of hydronephrosis, in contrast to conditions such as urinary tract inflammation, acute and persistent renal dysfunction, gross or microscopic haematuria.(15) This test can help spot possible health conditions,An X-ray exam of the urinary tract:-That uses a special dye to outline the kidneys, ureters, bladder and urethra. This test is called a CT urogram. It captures images of the urinary tract before and after urination.(16)

5.2. ADDITION TEST:- A normal renogram was found in all of the women in the control group. In the group of normal pregnant women a normal function was found on the left side in all, while in lo/27 the emptying the remainder the half-life of the right side first occurred after walking and in of excretion group. In the pre-eclampsia group, was prolonged in relation to the control there was normal excretion (but slightly pro- longed half-life) in while in the remaining commenced 23%. In another 23% there was normal emptying on one side 54% there was bilateral retention, after walking, inasmuch as emptying and in one half of these there was persistent first retention even after walking. Renography It is interesting was normal after labor in all of those studied.(17)

VI. TREATMENT OF HYDRONEPHROSIS

Analgesics:- To manage pain, your doctor may prescribe pain- relieving medication.Example:-paracetamol,ibuprofen,naproxen,aspirine,morphine,oxycodone.Anticholinergics:- For discomfort caused by ureteral stents ,medications like oxybutyline or tolterodine may be used. Example:-
Atropine,Diphenhydramine(Benadryl),Scopolamine,and oxybutynin. 10.3.Alpha- blockers:- These can also be used to help alleviate discomfort from stent.Example:- prozosin,terazosin,Doxazosin,Tamsulosin,Alfuzosin, and Sildosin. 10.4.Topical analgesics:- Medications applied topically, like phenazopyridine,can help with bladder irritation and spasm. Example:-Lidocaine,Capsaicin,Diclofenac,Benzocaine,menthol. Antibiotics:- These are prescribes to treat or prevent UTIs, which can causes or worsen hydronephrosis. They may also be given preventatively to infants at risk of infection.Example:- • Cephalexin • Nitrofurantoin • Trimethoprim • cotrimazole.(18)

VII. RECENT TRAETMENT AND INNOVATION FOR HYDRONEPHROSIS

7.1. Nanozyme-based therapy:- A 2025 study described a multifunctional targeted nanozyme that acts both as an ultra- Sound contrast agent and a therapeutic agent for congenital hydronephrosis – associated Renal fibrosis.This is

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very experimental ,but promising:it could help monitor (via ultrasound) And treat fibrosis in hydronephrotic kidneys. Scientist developed a pH -responsive nanozyme composed of PEG-SH(polyethylene glycol With a thiol) and imidazole -modified gold nanoparticals (AuNPs).These are called PMIZ- AuNPs.Enzyme like:- Superoxide dismutase (SOD)activity, catalase (CAT)activity.(19) It is activated under acidic condition.Mechanically,the nanozyme also downregulates Expression of a complement protein called C9 in the kidney.in animal (mouse)experiment, The therapy improved kidney structure (reduced fibrotic area, better cortical thickness) compared to controls.(20)

7.2. High pressure Balloon Dilation(HPBD):- An article published in 2025 evaluated the use of high-pressure balloon dilation in infants With primary obstructive meguareter (a cause of hydronephrosis).This is a minimally Invasive open surgery in some cases.However ,the study also reported a relatively high Complication rate,and not all infants avoided further surgery.A minimally invasive Endoscopic procedure used to widen a narrowed ureter and relieve obstruction that causes Hydronephrosis. How the procedure works :- 1) A small camera (cystoscope/ureteroscope) is passed into the bladder. 2) A high pressure balloon catheter is inserted into the narrowed part of the ureter. 3)The balloon is inflated at very high pressure (up to 20-30 atm). 4) This stretches and opens the obstruction. 5)A ureteral stent is usually placed for 4-6 weeks to keep the ureter open. 6) Hydronephrosis typically reduces over weeks to months.(21)

Use in Children :- A recent study (2025) evaluated HPBD in infants with primary obstructive megaureter:- • Some infants avoided surgery. • Procedure was successful in enlarging the ureteric opening. • Complication rate was relatively high, and some still required open/laparoscopic Surgery later, Advantages:- • Minimally invasive • Short hospital stay • Avoids open/laparoscopic surgery in selected patients • Good early success in some types of ureteral obstruction, Limitations:- • Not suitable for all causes of hydronephrosis • Success rate varies (50-80% depending on the study) • Some patients still need definitive surgery (reimplantation or pyeloplasty) • Complications may include vesicoureteral reflux or restenosis. Success rate:- • One review found a 71% success rate after 1HPBD and 79% after 2 dilations. • Complications rate in this review was ~33 %.(22)

VIII. CONCLUSION

Kidney-targeted drug delivery systems represent a promising Approach for the effective management of hydronephrosis by Ensuring therapeutic agents.directly to the affected renal tissues .These systems minimize systemic side effects , enhance drug Bioavailability, and improve treatment outcomes compared to Conventional therapies.help to summarise the diagnostic tools.

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