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Review Article

Complementary/Alternative Medicine Section

Review of Structural and Functional Anatomy of Kidney in Ayurvedic Literature with Special Reference to Diseases of the Kidney

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ABSTRACT

Description of organs and their treatment in Ayurvedic texts is very brief. In today's world when the diseases of organs like kidneys, heart, liver, and brain etc., are becoming very common, Ayurvedic practitioners find these descriptions inadequate to treat patients with such diseases. An effort was made to assess whether critical analysis of references related to kidneys in classical Ayurvedic texts provide inputs to an Ayurvedic Practitioner to understand the pathogenesis of Chronic Kidney Disease (CKD). *Tantrayukti* based interpretation of references of kidneys in classical Ayurvedic texts establishes that kidneys were known to, and are elaborately described in Ayurveda, with their anatomical details such as embryological origin, name, number, relation with other abdominal organs, location etc. They are known by the name of *Vrukka*, which are the abdominal organs that are two in number and are described as *Basti Marma* (which includes the kidneys, ureter, and Bladder) for the purpose of diagnosis, prognosis, and treatment of all urine related diseases. *Basti Marma* is one of the three *Maha Marmas* i.e., most important vital organs of the body viz., *Shiro* (~brain), *Hridaya* (~heart) and *Basti* (~bladders). *Vrukka* (kidney) is formed from the nutritious part of *Kapha, Meda* and *Rakta*, gives the inputs to the practitioner to consider the metabolism of these factors in diagnosis and treatment of CKD. Physiology of formation of urine is also elaborately described in Ayurveda. The reference of Sushruta which discusses about *Sahastrshaha Sukshma mukhani* (~ thousands of minute openings invisible to naked eye) where urine is formed resembles the description of glomerular filtration. Formation and processing by *Samaana*, role of *Jathar Agni, Dhatvagni* and *Bhutagni* in formation of *Mutra* (~urine), storage and excretion at the level of Bladder, by *Apaana* is defined clearly, and this description is of immense value for practitioners. Relation of *Basti Marma* to *Kleda* (~body fluids) and its pathological connection with specific diseases is also evident. Understanding of various factors viz., *Kleda* (~body fluids), *Marma* (~vital organs), *Prana* (~life force), *Oja* (~vitality), *Kalaa* (~Internal membranes) *Jathar Agni, Dhatvagni, Bhutagni* etc., and their role in pathogenesis of CKD provides *Vaidyas* with inputs to devise the line of treatment of patients suffering from CKD, taking into consideration the individual condition of each patient.

Keywords: *Basti*, *Marma*, *Vrukka*

INTRODUCTION

Currently, there is tremendous rise in the number of patients suffering from diseases of organs viz., Chronic Kidney Disease (CKD), ischaemic heart disease, diseases of the brain etc., [1-4]. Description of structure and functions of organs is perceived to be very brief in classical Ayurvedic texts. Students of Ayurveda find it difficult to fully comprehend the structure and their functions, which form the basis of diagnosis and treatment of such diseases in absence of elaborate description of these organs. *Tantrayukti* (~ Ayurvedic methodology of interpretation of the verses) is an important scientific tool described in Ayurveda to extract unlimited information from limited references. Here, we have demonstrated how we can derive essential information about the structure and function of kidneys from classical Ayurvedic texts using *Tantrayukti.* Previously we have published a study on the Ayurvedic principles for diagnosis and treatment of CKD and here we intend to describe the structural and functional aspects of kidney [5].

Methodology: Compilation of references related to kidneys and the urinary system from the *Samhitas* (~Classical Ayurvedic texts), that are scattered all over the texts was done. Collected references were indexed as per the logical sequence of information in such a way that it would provide the required information for a treating doctor about anatomy and physiology, and to assess whether it throws some light on the new aspects, regarding structure and functioning of kidneys. These references were used as the material for this research.

These references were interpreted on the basis of *Tantrayukti,* which is a tool described in Ayurveda to scientifically derive information from the textual quotes, as the standard guideline for interpretation of these quotes.

Uhya Tantrayukti to Unleash the Knowledge Hidden in Concise Sutras

References in Ayurvedic texts regarding kidneys, their functions, diseases etc., are very few. If we try to analyse the information with a standard approach it will not yield sufficient information that can be used for diagnosis and treatment of complex diseases like CKD. For this purpose, the use of "*Uhya*" *Tantrayukti* is recommended. *Charaka* states that it helps to derive the exact meaning of the text. *Tantrayukti* guides us to the exact meaning like a light in the dark [6].

Uhya Tantrayukti is used in conditions like these when the references are very few. This helps in getting unlimited information from limited references [7] and derives the information. A detailed analysis (collection, elaboration and expansion) of the following textual references regarding kidney was done using this methodology to understand the applied anatomy, physiology, pathogenesis etc., of CKD from the references scattered across the texts.

References of Kidney in Ayurvedic Literature

Detailed search of Ayurvedic texts (*Samhitas*) revealed that the detailed description of kidneys was known to Ayurvedic *Acharyas* along with their anatomy and physiology. The following reference of *Charaka Samhita* lists the abdominal organs in human body. Kidneys are called by the name of *Vrukka* in Ayurveda. In this reference *Vrukka* are described as one of the 15 *Koshthangani* (~abdominal organs)

[8]. These abdominal organs are *Nabhi* (~umbilicus), *Hriday* (~heart), *Kloma* (~pancreas), *Yakrut* (~liver), *Pleeha* (~spleen), *Vrukkau* (~two kidneys), *Basti* (~bladder), *Purishadhara* (~caecum), *Amashaya* (~gastrum), *Pakwashaya* (~part of large intestine), *Uttara guda* (~upper part of anus), *Adhara guda* (~lower part of anus), *Kshudrantra* (~small intestine), *Sthulantra* (~large intestine), *Vapavahanam* (~omentum).

There is mention of *Basti* (bladder) separately in the same reference along with *Vrukka*. Based on this, it was interpreted that Ayurvedic *Acharyas* were very clear that these two are separate entities. The dictionary meaning of *Vrukka* is kidney [9], also the word "*Vrukkau*" is used to describe them, which according to Sanskrit grammar is a dual form that means two *Vrukkas*. It is described as an abdominal organ. There is no other organ in the abdomen, which is two in number, apart from kidney. Hence, it can be clearly said that *Vrukka* refers to kidneys.

Secondly, if the reference is examined in detail, it will be known that the organs are described in groups like *Yakrut* and *Pleeha* (liver and spleen), *Uttara guda* and *Adhara guda*, *Amashaya* and *Pakvashaya*, *Kshudrantra* and *Sthulantra* and *Vrukka* and *Basti*. *Basti* here is explained as *Mutrashaya* i.e., reservoir of Urine which means bladder and the two organs connected to *Basti* can be none other than kidneys [6].

This inference is drawn based on "*Vidhana" Tantrayukti* described by *Charak* in *siddhi sthana. Vidhan Tantrayukti* specifies that there is a sequence and pattern to the information described in a stanza and is repeated and applied to other stanzas in the other part of the chapter [6].

Not only *Sushruta,* but *Charaka* also has used the word *Vrukka* for kidneys and he also has used the dual form suggesting two kidneys.

This reference is regarding the sites of abscesses that are formed internally. It says that when toxins enter the *Rakta* (~blood) and *Mamsa* (~muscles), the site of these organs is *gambhira* (~deep) and the condition thus generated is very *daruna* (~serious). There is description of organs where these abscesses are formed viz., *Hriday, Kloma*, *Yakrut*, *Pleeha*, *Vrukkayoho* (two kidneys), *Nabhi (umbilicus)*, *Vankshan* (~groins) and *Basti* [10]. Here, also there is separate mention of kidneys (*Vrukka)* and bladder *(Basti)* and dual form of the word *Vrukka* suggesting two in number is used. However, the word is not commonly used for kidneys elsewhere.

Embryological Formation of Kidney

Acharya Sushruta has even described the formation of kidney in the embryo. It says that *Vrukka* are formed from the *Sara* (the purest form) of blood (*Rakta*), lipids (*Meda*) and *Kapha* [11]. According to Ayurveda, the process of *Sara-kittavibhajan* (separation of nutritious part and excretory part) happens at the level of intestines by *Jathar Agni* (~digestive fire) [12] and also in the *Dhatus* (~tissues) by *Dhatvagni* (~factor responsible for metabolism of respective tissues) [12].

The *Sara-kittavibhajan* happens since the life in the womb and is continued till last breath. *Acharya Sushruta* has mentioned that the kidneys are formed from the metabolism of *Kapha dosha* and *Dhatus* (~ tissues), like *Rakta* (~blood) and *Meda* (~lipids). Metabolism is a continuous process in the body till the end of life. Any disruption in the metabolism of these *dhatus and doshas* is likely to adversely affect the functioning of these kidneys. *Vaidyas* must consider this process of *Sara-kittavibhajan,* which is reliant on the role of *Agni* and *Dhatvagni* in light of this reference, while treating patients of CKD.

In addition to kidneys, it also describes the formation of *Basti* i.e., bladder in this case. The purest form of *Rakta, Kapha,* is further transformed by *Pitta* in a different state and *Vayu* creates the space in these structures to form intestines, *Guda* (~anus) *and Basti* in the body, which means *Basti* here is referred as a reservoir along with other similar structures like intestines and anus [11]. Formation of bladder and kidney in the embryo is not the same and hence it is stated differently.

Charaka has also listed the formation of organs in the foetus from *Matruja Bhava* (~from the maternal parts of the genetic material). It says that, *Twak* (skin), *Rakta* (blood), *Mamsa* (muscles), *Meda* (lipids), *Nabhi* (umbilicus), *Hriday* (heart), *Kloma* (pancreas), *Yakrut* (liver), *Pleeha* (spleen), *Vrukkau* (two kidneys), *Basti* (bladder), *Purishadhara* (caecum), *Amashaya* (gastrum), *Pakwashaya* (part of large intestine), *Uttara guda* (upper part of anus), *Adhara guda* (lower part of anus), *Kshudrantra* (small intestine), *Sthulantra* (large intestine), *Vapa* and *Vapavahanam* (omentum) are all created predominantly from the maternal part of genes [13].

While describing *Vrukka, Dalhan* the commentrator of *Sushruta Samhita* explains what *Sushruta* means by *Vrukka* and their location. *Mamsa pinda dwayam* (~two muscular) structures *Ekovama parshva stitaha* (~one situated on the left lateral side) and *dwitiyo dakshin parshva sthithiha* (~other at the right lateral side).

These references show that kidneys were known to Ayurvedic *Acharyas* with their anatomical details such as embryological origin, name, number, relation with other abdominal organs, location etc.

The term *Basti* is used several times in Ayurvedic texts in different contexts at different places. This creates lot of confusion in its interpretation especially while discussing *Mutraghata* (~anuria) and other diseases of the urinary system.

After careful analysis of most of the references, it was observed that the term *Basti* is used mainly with three meanings:

i. *Basti-Marma* (~vital organ)
ii. *Basti-Mutrashaya* (~bladder)
iii. *Basti*-One of the five main *Panchakarma* procedures

Ashtanga Sangraha further clears the confusion arising for the use of *Basti* in different contexts.

This description says that *Basti* described in chapter of *Marma* is the seat of all diseases related to urinary system. Here, *Basti* is used as alternative word for *Vrukka* i.e., kidneys. In this reference it seems that the term *Basti Marma* is used collectively for kidney, ureters and bladder. It says that *Basti* is like a pot turned upside down which is filled laterally with the fluid called urine formed in thousands of minute openings and collected by ureters [14].

It says that *Basti* is the seat of all diseases related to urinary system. It is described in the chapter of *Marma*.

It clearly implies that the word *Basti* used here refers to *Basti Marma*. This is derived based on *"Adhikaran" Tantrayukti*, which says that the meaning of the word must be inferred after considering the context in which it is described. It says that *Adhikaran* is the subject or the context that has been kept in mind by the author while describing a subject [7].

Hence, it clearly implies that the word *Basti* used here refers to *Basti Marma*. It also says that it looks like a pot turned upside down, which is filled with a fluid called urine that is formed from thousands of small openings. Through these same openings the *dosha's* and the diseases also enter the urinary system or set of organs. This description matches with the description of kidneys, ureters, and bladder. There is a mention of thousands of minute openings in which urine is formed, this can be easily interpreted as nephrons [15]. This shows that the structure of nephrons and glomerular filtration was also known to and described by Ayurvedic texts.

Location of Kidney

In the chapter of *Marma* while describing *Basti Marma, Charaka* says that '*Basti*' is situated in between *Sthulaguda* (~part of large intestine), *Mushka* (~testes), *Sivani* (~junction of two testes), *Shukravahanadi* (~vas deferens), *Mutravahanadinam* (ureters) madhye [16]. It is also referred to as the end point of fluid metabolism comparing it to the ocean to which all the water channels ultimately meet. *Udadhi* means ocean and *Apaga* means water channels, *Pratishtha* here means end point [9].

Ashtanga Sangrah describes *Basti* as a structure which is curved like a bow having one opening [17]. This bow like curve refers to the outer curvature of kidney and one opening refers to the opening of ureter. Whereas *Basti* as *Mutrashaya* is described as pot turned upside down. In the lower back of the abdomen *Basti Marma* is a bow like structure having one opening.

Another reference of *Sushruta* clearly describes the location of kidneys and its relation to other organs in an elaborate manner. It says that *Basti* is situated between these structures *Nabhi* (umbilicus), *Prushtha* (~back), *Kati* (~lower back), *Mushka* (~testis), *Guda, Vankshan* and *Shefas* (~penis) [15].

This reference explicitly says that *Basti (*~kidney*), Basti Shira (*~bladder*), Paurusha (*~penis*), Vrushanau* (~two testes) are directly connected to each other and are situated in the *Gudasthivivar* (~pelvis) and are kept hanging in the place by *Sira* (~vessels) and *Snayu* (~ligaments) like a *Alabu* (bottle gourd) on the plant [15].

If we view these references along with the description by *Dalhana,* that the *Vrukka* are located on two lateral sides in the lower abdomen (*Kukshi*), we get a clear picture of the *Basti Marma* i.e., kidneys.

These references indicate that the location of *Basti* is between large intestine and ureters, and that whole urinary system is called *Basti Marma*. The description of curved shape from back side and having one opening is suggestive of kidney. However, the term *adhomukho* i.e., having opening to the lower side refers more to bladder. The use of *dwivachana* (dual form) in the commentary and saying that when both the *Basti* are injured the death is sure and immediate, also suggest kidney.

Marma is another anatomical feature described exclusively by Ayurvedic texts which means vital points in the body. The precision in description of these *Marmas* is that they have described minute details of these *Marmas* i.e., their number (107), exact location, measurement, and composition *(Mamsa, Sira, Asthi, Sandhi* etc.,). These *Marmas* are so vital that damage to it can be fatal and even slight damage to these, can lead to serious diseases [16].

Basti Marma is one of the three most important *Marma*, due to its importance and it is referred as *Mahamarma*. This description of three *Maha Marmas* correlates with the description of *Shiro* (brain) *Hriday* (heart) and *Basti* (kidney) and we all know how important these organs are for the continuation of life [16].

However, this correlation is not merely for theoretical purpose, the fact that kidney can be related to *Basti Marma* opens completely new areas for diagnosis, prognosis, and treatment options for diseases of kidney. It also gives a clear understanding of the kidneys in Ayurveda and helps to formulate the line of treatment of such diseases.

Marma, specifically the three *Maha Marmas* (the major vital organs) are the seat of *Prana*, the life force [16] and since *Basti-Marma* is one of the three major *Marmas* in the body, it is obvious that existence of our life is grossly dependant on *Basti Marma* i.e., kidney.

It has been stated that the *Pranas* are located in these three *Maha Marmas*. Hence, one should always try to protect them. The protection plan for *Maha Marmas* is described as having three aspects one is prevention of damage (external injury and internal damage), second is following the recommended lifestyle (Diet, *Dinacharya* and *Rutucharya* etc.,) and third is attending to the complaints of these *Marmas* immediately [16]. It also means that we must think of *Prana* as a factor in the treatment of diseases of kidney.

Prana is directly connected to *Oja* since it is related to life. It is said in the references that if *Oja* is damaged the life is at threat [18] and it is also evident from this reference that *Oja* and *Prana* are in conjunction with each other, which means wherever *Prana* is present *Oja* is also present and vice versa [19].

Sushruta also has elaborately described the applied anatomy of *Basti* and other allied organs while describing *Ashmari* (~renal calculi) in the same way, along with the famous description of formation of urine (applied Physiology). He has mentioned *Basti* and *Mutrashaya* in the same verse suggesting *Basti* as *Basti Marma* which he says is *Pranayatana* (seat of *Prana*) and *Mutashaya* as bladder [15]. This is confirmed by *Dalhana* in the description of *Basti Marma* [20].

If the references are viewed along with the description by *Dalhana,* that the *Vrukka* are located on two lateral sides in the lower abdomen (*Kukshi*), a clear picture of the *Basti Marma* i.e., kidneys is evident.

Description of Physiology of Kidney in Ayurveda

Ayurvedic texts have elaborately described the process of formation of urine. It is comparable with process of glomerular filtration described by modern medicine [15]. Additionally, it gives importance to the role of *Agni* in the formation of urine at initial stages.

The meaning of the stanza is as follows:

- The ureters in *Pakvashaya* fill the urine continuously like the rivers pouring in the ocean.
- Urine is generated in the *Amashaya* through thousands of openings which cannot be seen with naked eye because they are extremely minute.
- This process is going on continuously day and night while being awake or in sleep. Urine is filled drop by drop from two lateral sides in the *Basti* which looks like a pot turned upside down.

The *Acharyas* say that asamsahastrashahamukhani (~ the thousands of openings) are not visible by the naked eye as they are *Sukshma* (~very small). This description is quite like the description of glomerular filtration at the nephrons which separate urine from blood. It is evident that Ayurvedic *Acharyas* are aware of nephrons as the basic generating units of urine, all this description must be viewed in light of the fact that there was no microscope, or any other machine which may help to visualise it. *Ashtanga Sangraha* and *Sushruta,* both have described it in exactly the same way [11,15].

The mention of *Amashaya* (~proximal part of alimentary canal), the seat of *Agni*, in the process of formation of urine is something unique described in Ayurvedic texts. This reference is therapeutically very important. *Acharya Dalhana,* the commentrator of *Sushruta Samhita* has elaborately dwelled upon the role of *Amashaya* in the formation of urine. To understand it in the context of modern medicine we can consider it as an intestinal factor in the formation of urine (explained as *Purishdhara/Maladhara kalaa*) like the intestinal factor in the formation of blood. *Acharya Dalhana* has also discussed the extent of area that the *Purishdhara/Maladhara kalaa* covers [20].

Stools and urine are collectively referred to as *Mala* (~metabolic waste products) in Ayurveda and are formed from digestion of the food [12]. This process is called as *Sara-kittavibhajan,* which means separation of *Sara* (~nutritious part) and *Kitta* (~excretory part) from the food that is digested. *Kitta* is the synonym of *mala.* The etymology of the word मल (*Mala)* in Sanskrit specifies the exact meaning. *Malinikaranatmalaha* means *mala* which, if retained in the body causes serious toxic build up in the body.

Jathar Agni (~main digestive fire) is the most important factor responsible for this, *Sara-kittavibhajan* i.e., primary or first level of separation. The solid form of *Mala* is *Purisha* or faecal matter, which excretes the non-water-soluble part whereas the liquid part is called as *Mutra* or urine, which excretes the water-soluble part of metabolic waste that is generated [12].

Another reference of *Sushruta* says that the process of formation of urine starts in *Purishadhara kalaa* (~membrane which carries out the function of separation of nutrients and excretory products) in the intestine. They have even described the area covered by *Purishadhara kalaa* which is also called as *Maladhara kalaa* [20]. In the context of formation of urine, the membrane where separation *of Rasa and Mala* happens, is called as *Purishadhara kalaa.* It is the fifth one, which is situated in the *Pakvashaya* (~distal part of alimentary canal). It separates the *Mala* into *mutra* (urine) and

Purisha (~faecal matter) in the intestine. It is spread over in the abdomen in the periphery of liver, covering intestines till caecum and rectum. This is the second level of separation occurring at the level of glomerular filtration.

Since *Kalaa* is like a membrane between the tissue and the cavity entitled with separation of urine, part of *Maladhara kalaa* pertaining to urine generation, described in Ayurvedic texts, may refer to structure of glomerulus, which is open for discussion [11,20].

Kalaa written as '*कला*' *in Devanagari* script is a very typical anatomical structure described in Ayurveda *Sharir*. In Ayurvedic texts *Twacha* (~ skin) is described as an external covering and *Kalaa* as an internal lining. It can be translated as a membrane, in Ayurvedic texts it is defined as separation between the tissues and the cavity [11].

On looking at the detailed description of the *Kalaas,* it will be evident that they are placed at strategic locations where lots of metabolic, transformational and transport related activities are happening e.g., liver-spleen, muscle tissue, blood vessels, intestines, omentum, bone marrow, internal spaces of joints etc. In the context of this description of *Kalaa*, the uterus, and its connection with *Rasa-rakta* is also mentioned.

The process of formation and storage of urine are described separately. This is evident from the fact that these functions are assigned to two different types of *Vayu* viz., *Samaana* and *Apaana, Samaana*-responsible for separation of *Rasa*, urine and stool from the process of digestion of food i.e., for formation of urine and *Apaana*- responsible for storage (when the urge of urine is not there) and excretion of urine (when there is urge of urination) [21].

Samaana is traditionally known to be helping in kindling the digestive fire, but detailed analysis of the textual references throws up new dimension of functions of *Samaana*, it not only facilitates the functions of *Jathar Agni* i.e., the main digestive fire but also facilitates the function of *dhatvagni* i.e., the metabolism at tissue level and *Bhutagni* the metabolism at the level of five basic elements. This inference can be drawn based on following reference of *Charaka Samhita*.

According to *Charaka Samhita*, the area of operation of *Samana* extends up to *Swedavaha srotas* i.e., channels of sweat which means originating from lipid tissue and extending up to pores of skin, *Ambuvaha srotas* i.e., all fluid channels and all fluids in the body and also the *Doshavaha srotas* which extends up to each and every cell of the body [22] as *Doshas* are omnipresent according to Ayurveda. This means the area of operation of *Samana Vayu* is whole body. It regulates the core body temperature and heat metabolism of the body with *Agni* which is also known as *Ushma*. The most important fact is that it regulates the balance of heat and water in the body and hence plays an important role in the formation of urine and sweat from the food in the digestion process [23].

Samanaa type of *Vayu* is assigned the job of second level of separation which happens at the level of *Dhatvagni* i.e., tissue level. The third level of separation happens at the level of kidneys which is evident from the description of formation of urine described by *Sushruta Samhita* [15]. The formation of urine according to Ayurveda starts in *Pakwashaya*, part of large intestine and is taken forward in *Basti Marma* i.e., kidneys, large intestine is connected to *Basti Marma* by way of *Adhoga Dhamani* [23].

The purpose of urine according to Ayurvedic texts is to process the fluids in the body along with the liquid part of excretory products (excrete the water-soluble metabolic wastes) [24].

This reference if read in connection with other reference which says that urine is formed in the *Basti Marma* by thousands of minute openings makes it crystal clear that it was known to Ayurvedic experts that urine is generated through glomerular filtration and the metabolic soluble waste products need to be excreted out failing which can create serious disease conditions.

Kleda or body fluids are another important concept of Ayurveda that is useful to understand the pathophysiology of CKD. The extent and meaning of *Kleda* and its normal quantity in a healthy body has been elaborately explained by *Charaka Samhita.* The concept of *Kleda* encompasses the fluids that are taken away in loose motions, urine, watery content of blood, the moistness of the skin, the serous discharge from the wounds, sweat etc., [8].

This *Kleda* is connected to the *Basti Marma* as is clearly described in the following reference [16] as endpoint of fluids. Since *Kleda* encompasses all fluids in all tissues of the body it is very rightly considered as an important factor in the pathogenesis of many diseases like *Udara* (~ascites)*, Shotha* (~oedema)*, Madhumeha* (~diabetes)*, Mutravikar* (~diseases of urinary system) etc.

Hence, for a practising *Vaidya,* it is important to note that formation of *Mutra* (~urine) happens at three levels; first at the level of *Jathar Agni,* in *Amashaya.* Second at the level of *Purishadhara kalaa in Pakwashaya* and at the level of *Dhatvagni* by *Samaana Vayu,* because to carry out all the metabolic excretory products is the role of *Mutra,* which is spread all over the *Dhatus* and third at the level of *Basti Marma* i.e., kidneys by *Bhutagni* particularly *Apya Agni.* A *Vaidya* can ascertain the level at which there is disruption of formation of urine and treat accordingly.

From the above references it may be said that physiology of formation of urine is elaborately described in Ayurveda including formation, processing, storage, and excretion defined clearly. It's relation to *Kleda* and its pathological connection with specific diseases is also evident from the above references.

Summary and Observations

All these references show that:

1. Kidneys were known to Ayurvedic *Acharyas* with their anatomical details such as embryological origin, name, number and their relationship with other abdominal organs, location etc.
2. Kidneys were known as *Vrukka* and bladder was referred to as *Basti*. Kidney and bladder are described separately as abdominal organs connected to each other where kidneys are two in number and bladder as one.
3. The bladder is described like a pot turned upside down filled from the sides. Whereas kidney is described as structure having single opening and curved bow like structure.
4. Embryological formation of kidneys are from *Rakta, Kapha* and *Meda*, whereas bladder, intestines, and Anus are formed from *Rakta* and *Kapha* by *Pitta* and *Vayu.*
5. The fact that embryological formation of kidneys and bladder described in Ayurveda is different emphasises that it was known to Ayurveda that the structure and function of these two entities is altogether different.
6. The term *Basti* is used in various contexts, in the context of *Marma* it refers primarily to kidneys and collectively to kidneys, ureter and bladder.
7. It can be interpreted that *Basti Marma* refers to kidney. Brain (*Shiro*), heart (*Hriday*) and kidney (*Basti*), are the three vital organs of the body, referred to as *Maha Marmas* of the body.
8. The main function of urine according to Ayurveda is to excrete the processed fluids (metabolic waste products in liquid form) i.e., *Kleda* of the body. This *Kleda* is spread all over the body and encompasses all fluids in all the tissues. *Basti Marma* i.e., kidneys are the end point of all fluid metabolism in the body.
9. Hence, urine is connected to *Basti Marma* and urine formation is the main function of *Vrukka/Basti Marma*.
10. The structure of nephrons and glomerular filtration was also known to and described by Ayurvedic texts.

11. Formation of urine at the first level is done by separation by *Jathar Agni* in the intestines, at the second level by *Samana Vayu* in the *Purishdhara kalaa* in the intestines and the third level by *Aapya Bhutagni* at the *Maladhara kalaa* in the *Basti Marma* (glomerular filtration).
12. *Maladhara kalaa* also called as *Purishdhara kalaa* is a membrane, that does the function of separation/filtration of urine and is spread in liver, intestines, and kidney.
13. Area of operation of *Samana Vayu* is whole body and it is connected to sweat glands, all fluids, and *Agni*. It regulates the core body temperature and helps in maintaining fluid balance and hence is connected to intestines and kidneys.

DISCUSSION

Kidneys were known as *Vrukka,* their structure i.e., anatomical details such as embryological origin, name, number, relation with other abdominal organs, location etc., is elaborately mentioned. It gives important inputs to the practising *Vaidya* so as to understand the pathogenesis of CKD.

Since kidneys are identified as *Maha Marma,* it is seat of *Prana* (~ the life force) and *Oja* (~vitality). The methodology of treating diseases of *Marma* and of *Oja* are described in Ayurvedic texts. Those can be used as guidelines for devising the line of treatment.

Description of embryological formation of kidneys from *Rakta, Meda* and *Kapha* is an important guideline for a practicing *Vaidya* to look for disruption in the metabolism of these factors as a clue to understand the pathogenesis of CKD.

Kidneys through *Basti Marma* are an end point of all fluid metabolism in the body. All fluids are denoted by *Kleda*, the function of *Mutra* is to carry out the excess *Kleda* in the body. Metabolism cannot happen without *Agni;* hence it is the seat of *Aapya Agni* one of five *Bhutagni.*

Jathar Agni, Dhatvagni and *Bhutagni* all are involved in the formation of urine according to Ayurveda. *Samaana Vayu* is connected to formation of urine and *Apaana Vayu* is connected to storage and excretion of urine.

CONCLUSION(S)

Structural and functional anatomy of kidney revealed from critical analysis of description related to kidney in classical Ayurvedic texts provide vital information for a practising *vaidya.* This description illustrates that the physicians of the past era had in depth knowledge of the renal system.

Disclaimer: This paper is being published to highlight the ancient understanding of human anatomy and physiology. However, readers are cautioned that the medicine has evolved with better methods of investigation and more evolved understanding.

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APPENDIX

Glossary of Sanskrit/Ayurvedic terms and their meanings.

S. No.	Sanskrit/Ayurvedic Term	Meaning
1	*Tantra yukti*	Ayurvedic methodology of interpretation of the verses/tools of interpretation
2	*Uhya Tantrayukti*	Name of the tool 'Uhya' meaning logic
3	*Adhikaran Tantrayukti*	Name of the tool 'Adhikaran' meaning context
4	*Vidhana Tantrayukti*	Name of the tool 'Vidhana' meaning sequence
5	*Vayu*	An Ayurvedic term for the functional unit, first of the three 'dosha' of the body, also known by the name of *Vata*, written in Devnagari as **'वायु'** or **'वात '** controlling all functions related transportation, signaling, voluntary and involuntary movements, excretion, expulsion of fetus in the females while delivery etc
6	*Pitta*	An Ayurvedic term for the functional unit, second of the three 'dosha' of the body, written in Devnagari as **'पित्त'** controlling all functions related to metabolism, digestion, anger, heat, nutrition etc
7	*Kapha*	An Ayurvedic term for the functional unit, third of the three 'dosha' of the body, written in Devnagari as **'कफ'** controlling all functions related to lubrication, growth, stability, peace etc
8	*Vrukka*	Kidneys
9	*Basti marma*	Term collectively used for kidneys, ureter and bladder
10	*Maha marmas*	Major three vital organs of the body
11	*Rakta*	Ayurvedic term used for blood
12	*Mamsa*	Ayurvedic term used for muscles
13	*Meda*	Ayurvedic term used for lipids
14	*Jathar agni*	Ayurvedic term used for the digestive fire, factor responsible for digestion and nutrition one of the thirteen *agni*
15	*Dhatvagni*	Ayurvedic term used to denote metabolism in the tissues, these are seven types pertaining to seven tissues of the body, called as *'dhatus'*
16	*Bhutagni*	Ayurvedic term used to denote the metabolism of five elements (viz., Earth, water, fire, air, and ether)
17	*Mutra*	Ayurvedic term used for Urine, one of the three main excretory products of the body formed from all fluids in the body filtered from blood
18	*Sahastrshaha sukshma mukhani*	Sanskrit words meaning thousands of minute openings, sahastra means thousand, when shaha is added it means thousands, sukshma means minute, mukhani is a plural form of mukha which means openings
19	*Kleda*	Ayurvedic term used for body fluids
20	*Marma*	Ayurvedic term used for vital organs
21	*Prana*	Life force, also one of the five type of vayu controlling the functions head, neck and thorax and responsible for nutrition of predominantly heart, brain, sensory organs etc
22	*Oja*	In Ayurvedic terminology it means vitality.
23	*Apana*	One of five types of *Vayu* controlling the functions in the lower part of the body
24	*Kalaa*	Ayurvedic term used for internal membranes
25	*Vaidyas*	Ayurvedic term used for physicians
26	*Samhitas*	Classical Ayurvedic texts
27	*Charaka Samhita*	Name of an Ayurvedic classical text
28	*Sushruta*	Name of an author of *Sushruta Samhita* Ayurvedic classical text
29	*Shiro*	Ayurvedic term used for place holding Brain
30	*Hridaya*	Ayurvedic term used for Heart
31	*Basti*	Ayurvedic term used for kidneys in the context of *Marma*
32	*Koshthangani*	Koshtha is the term used for abdomen in Ayurvedic terminology angani is the term used for organs, the word collectively means abdominal organs
33	*Nabhi*	Ayurvedic term used for umbilicus. Considered as an organ, also a *Marma* or a vital point
34	*Kloma*	Ayurvedic term used for pancreas
35	*Yakrut*	Ayurvedic term used for liver
36	*Pleeha*	Ayurvedic term used for spleen
37	*Vrukkau*	Dual form of word vrukka meaning two kidneys
38	*Purishadhara*	Ayurvedic term used for Caecum
39	*Amashaya*	Ayurvedic term used for Gastrum
40	*Pakwashaya*	Ayurvedic term used for part of large intestine
41	*Uttara guda*	Ayurvedic term used for upper part of anus
42	*Adhara guda*	Ayurvedic term used for lower part of anus
43	*Kshudrantra*	Ayurvedic term used for small intestine
44	*Sthulantra*	Ayurvedic term used for large intestine
45	*Vapavahanam*	Ayurvedic term used for Omentum
46	*Mutrashaya*	Ayurvedic term used for reservoir of urine which means bladder
47	*Mamsa pinda dwayam*	Two muscular structures
48	*Gambhira*	Deep
49	*Daruna*	Serious
50	*Acharya*	Revered teacher
51	*Sara*	Ayurvedic term used for the purest part form formed out of metabolism
52	*Kitta*	Ayurvedic term used for the excretory part formed out of metabolism
53	*Sara-kittavibhajan*	the process of separation of nutrients and excretory products from the food
54	*Agni*	Ayurvedic term used for digestive fire
55	*Guda*	Ayurvedic term used for anus
56	*Matruja bhava*	Formed from the maternal parts of the genetic material. Ayurveda had described the formation of various parts and organs of the human body from certain tissues
57	*Pranayatana*	*Prana* means life force and ayatana means seat, pranayatana means Seats of *Prana*. certain places in the human body where life force is concentrated
58	*Purisha*	Ayurvedic term used for faecal matter
59	*Eko vama parshva stitaha*	First one situated on the left lateral side
60	*Dwitiyo dakshin parshva sthithiha*	Second one situated at the right lateral side
61	*Mutraghata*	Ayurvedic term used for Anuria
62	*Panchakarma*	Ayurvedic term used for the five therapeutic procedures used for detoxification/cleansing
63	*Ashtanga Sangraha*	Name of a Classical text of Ayurveda
64	*Basti shira*	Ayurvedic term used for Bladder
65	*Paurusha* or *shefas*	Ayurvedic term used for Penis
66	*Prushtha*	Back
67	*Kati*	Lower back
68	*Mushka*	Ayurvedic term used for testis
69	*Vankshan*	Ayurvedic term for groin

70	*Vrushanau*	Two testes
71	*Sira*	Vessels
72	*Snayu*	Ligaments
73	*Alabu*	Bottle gourd
74	*Kukshi*	Lower abdomen
75	*Adhomukho*	Having opening to the lower side
76	*Dwivachana*	Dual form
77	*Asthi*	Ayurvedic term for bones
78	*Sandhi*	Ayurvedic term for joints
79	*Maha marmas*	The major vital organs
80	*Prana*	The life force
81	*Dinacharya*	Regimen of recommended activities done every day
82	*Rutucharya*	Regimen of recommended diet and activities as per the seasonal changes
83	*Oja*	Vitality
84	*Ashmari*	Renal Calculi
85	*Dalhana*	Name of the commentrator of sushruta samhita an Ayurvedic classical text.
86	*Pakvashaya*	Distal part of alimentary canal
87	*Amashaya*	Proximal part of alimentary canal
88	*Purishdhara/Maladhara kalaa*	Membrane which carries out the function of separation of nutrients and excretory products
89	*Mala*	Metabolic waste products
90	*Malinikaranatmalaha*	Which means *mala* are those who if retained in the body causes serious toxic built up in the body
91	*Kalaa*	*Membrane between the tissue and the cavity*
92	*Swedavahasrotas*	Channels of sweat
93	*Ambuvahasrotas*	All fluid channels and all fluids in the body
94	*Doshavahasrotas*	The Channels through which the three doshas move around in the body
95	*Adhoga dhamani*	Ayurvedic terminology for vessels and/or nerves, plexuses of lower part of the body
96	*Udara*	Ascites
97	*Shotha*	Oedema
98	*Madhumeha*	Diabetes
99	*Mutravikar*	Diseases of urinary system
100	*Apya Agni*	Ayurvedic term for metabolism in all fluids