Ureteral stenting has become one of the most common endoscopic procedure in endourology. Its main purpose is to preserve urinary drainage if this is compromised and maintain a good renal function. Even if there were made significant improvements in the last 50 years, ureteral stenting is not without morbidity. The common ureteral stents cannot have a good long-term efficiency and at some points, it will be blocked by the encrustation and incrustation; as result, the urinary drainage will have to suffer. A total of 134 ureteral stents in 83 patients suffering from reno/ureteral lithiasis were examined. We investigated the risk factors of encrustation and analyzed the chemical compounds of it. A total of 57 stents were found encrusted. The main risk factor was represented by the indwelling time. The rate of encrustation was 18.33% in the first 5 weeks, 56% between week 6 and 12, 75% thereafter. Stents with a smaller caliber (4.8 CH) tend to be more encrusted than those with a bigger one (6 CH). The Fourier Transform Infrared Spectroscopy has found that the main chemical compound of encrustation is represented by calcium oxalate.

Key words: encrustation, ureteral double J stent, urolithiasis.

For the first time Finney and Hepperlen used modern double JJ ureteral stent in 1978 [1], however, the first ureteral stent placed trough cystoscopy was performed by Zimskind and Associates in 1967 [2]. These two events marked a new era in the management of urolithiasis, acute obstructive renal failure and renal colic, especially in cases where extracorporeal wave lithotripsy or pharmaceutical management were ineffective [3,4]. Thereby, the double JJ has become one of the most used endoscopic procedures [5]. These particular cases were at risk of developing chronic renal failure, due to permanent obstruction and underlying hydronephrosis [6,7]. Throughout the time, the ureteral stent have suffered significant changes regarding its design and material, however the ideal ureteral stent hasn’t been developed yet [3].

When the stents contacts urine, its biomaterial enters in a reaction with the organic materials, uropathogens and urinary salts [8]. The primordial effect on encrustation it’s caused by urinary tract infections that form an organic lair on the stents; the reports show that most of the stents are colonized with bacteria (68%-90%) even this the bacteriuria is present in 27-30% of cases [9,10].

Our main goal of this study was to evaluate the risk factors of encrustation within the patients with reno-ureteral lithiasis. The second goal is to evaluate the chemical composition of the encrustation.

Experimental part
Materials and methods
A total of 134 ureteral stents in 83 patients known with urolithiasis were investigated in our center between September 2017 and August 2018. Informed consent was obtained from all the patients. The stents were extracted with the following types of anesthesia: local, sedoanalgesia or general anesthesia. After the extraction of the JJ stents, those were examined for the grade of encrustation and the modification of the color. Also, it was examined the situs of encrustation (proximal/distal volute or body of the JJ stent). In case of presence of encrustation, those were sent to the lab for mineralogical exam (FT-IR); the lab results were divided in 2 big categories: single-compound and mixt stones. The encrustations were divided in two groups (sever encrustation and moderate encrustation).

The level of resistance that was required to extract the stent was divided in 3 grades. Easy to extract- there were no resistance in the extraction. Moderate resistance – the stent that required more time to be extracted cistoscopically. Irremovable -the stents that required other interventions then cistoscopical extraction. The modification of the color was divided in two groups: stents with minimal modification of the color on at least ½ of the distance; and stents with essential modification of the color on at least ¼ of the distance.

Statistical analysis
The statistical analysis was accomplished with the help of Epilinfo 7.2.2.6 created by CDC USA.

Results and Discussion
A total of 134 ureteral JJ stents were extracted from 83 patients. All the stents were placed cistoscopically for the ureteral/renal lithiasis. Of the total 134 stents: 20 patients had 2 replacement, 9 patients had 3 or more replacement. All the ureteral JJ stent was made of polyurethane. Table 1 shows characteristics of patients and ureteral stents. From 134 of stents, the encrustation was observed in 57 of cases (42.5%). Of these, 32 (23.36%) had more than one situs of encrustation. Table 2 shows location and grade of encrustation.

A smaller caliber stent (4.8 CH) was more frequent encrusted in comparison with a larger one (6 CH) being significantly correlated (p=0.031) (fig. 1).
Of 134 ureteral stents 20 (14.92%) JJ stents needed more time for extraction; and 4 (2.98%) of them were irremovable and needed other urological procedures for extraction.

The indwelling time is a primordial risk factor in the encrustation. Stents with a bigger indwelling time had a greater chance to be encrusted with significant correlation between them ($p = 0.0000000669$). The correlation was shown in Figure 2. At the same time stents with a bigger indwelling time have greater rate of modification of color than those extracted in the first 5 weeks ($p = 0.003293$), correlation that is presented in Figure 3.

Even though there were no significant correlation between the resistance at the extraction of the stent and the indwelling time, the trend seems to be: a greater indwelling time may be associated with a greater effort that will be needed to extract the stent (8.33% in the first 5 weeks vs 18% at week 7-12 vs 25% thereafter), as it is shown in Table 3.

Fourier Transform Infrared Spectroscopy determined that the most encrustations were mix-compound (64.91%). Calcium Oxalate Monohydrate (22.81%) represented the main encrustation in the single-compound group. The proportion of different kind of encrustation was shown on Table 4. The urinary culture was positive in 24.63% (33 patients).

Finney and Hepperlen used the modern ureteral JJ stents for the first time in 1978. Since then, a lot of materials and coatings have been developed to prevent the complications [1,11]. Although there are a lot of factors that influence the

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**Table 1**

| Variables                  | Number (% or range) |
|----------------------------|---------------------|
| No. of stents              | 134                 |
| No. of patients            | 83                  |
| Median age (years)         | 53.6 (19-78)        |
| Sex                       |                     |
| Male                       | 47 (36.62%)         |
| Female                     | 36 (43.38%)         |
| Side                       |                     |
| Left                       | 72 (53.73%)         |
| Right                      | 62 (46.27%)         |
| Median indwelling time (d) | 49.7 (4.1-78)       |
| Stent caliber              |                     |
| 4.8 Ch                     | 18 (13.43%)         |
| 6 Ch                       | 116 (86.57%)        |
| Stent length               | 26 cm               |

**Table 2**

| Encrustation      | Proximal | Body | Distal |
|-------------------|----------|------|-------|
| Encrusted         | 31       | 13   | 23    |
| Moderate encrustation | 26     | 10   | 19    |
| Sever encrustation | 5       | 3    | 4     |

**Table 3**

| Characteristics                      | <6 weeks | 6-12 weeks | >12 weeks |
|--------------------------------------|----------|------------|-----------|
| No. of stents                        | 60       | 50         | 24        |
| Encrusted stents                     | 11 (18.33%) | 28 (56%) | 18 (75%) |
| Moderate encrustation                | 8 (13.33%) | 20 (40%)  | 11 (45.83%) |
| Sever encrustation                   | 3 (5%)   | 8 (16%)    | 7 (29.17%) |
| Color changes                        | 3 (5%)   | 5 (18%)    | 8 (33.33%) |
| Minor changes                        | 2 (3.35%) | 7 (14%)    | 6 (25%)   |
| Essential modification                | 1 (1.67%) | 2 (4%)     | 2 (8.33%) |
| Resistance at the extraction         | 5 (8.33%) | 9 (18%)    | 6 (25%)   |
| Moderate resistance                  | 4 (6.66%) | 8 (16%)    | 4 (16.66%) |
| Irremovable                          | 1 (1.66%) | 1 (2%)     | 2 (8.33%) |

Fig. 1. The correlation between the stent caliber and encrustation

Fig. 2. The correlation between the indwelling time and encrustation

Fig. 3. The correlation of indwelling time and encrustation
occurrence of encrustation such as: lithiasis, urinary sepsis [12], systemic malignancy [13,14], chemotherapy [15], urinary tract malignancy [16], pregnancy [17, 18], chronic kidney disease [19] and metabolic abnormalities, the indwelling time remains the primordial factor affecting the rate of encrustation [20-24]. More rare, other comorbidities or treatments may have an influence on the rate of encrustation [25-32].

As mentioned earlier, the indwelling time is the main variable that affects rate of encrustation. El-Faqih and Kawahara indicated that the rate of encrustation on ureteral stents was 9.2-26.8% in the first 5 weeks, 47.5-56.9% between week 6-12, and 75.9-76.9% after 12 weeks [33,34]. Our article supports the earlier mentioned data: the ureteral stent encrustation on the stents with indwelling time less than 6 weeks was 18.33, 56.9% between week 7-12 and 75% thereafter. The most encrusted situs was the proximal end or also called the upper curl followed by the distal curl and body (Table 2). Singh el al. reported that the most encrusted situs is the upper curl [35]. The presence of encrustation on the superior part of the stent may have been greater because the inferior part of the stent and the body are affected by a greater peristalsis that washes away the debris [32, 33, 36].

The stent caliber is another import variable that affects the encrustation. The study on encrustation and incrustation has determined that the incrustation precedes encrustation [34], therefore a stent with a greater caliber will have a bigger indwelling time. The main compound of the stent encrustation is represented by calcium oxalate that is no different from the reno/ureteral lithiasis so the pathophysiology of the stent encrustation seems to be very similar to that of the urinary lithiasis.

Table 4
PROPORTION OF DIFFERENT KIND OF ENCRRUSTATION

| Encrustation compound | No. | Rate(%) |
|-----------------------|-----|---------|
| Calcium Oxalate Monohidrat (COM) | 13 | 22.81 |
| Apatite | 1 | 1.75 |
| Uric acid | 3 | 5.27 |
| Struvite | 2 | 3.51 |
| Cystine | 1 | 1.75 |
| Mix | 37 | 64.91 |
| COM+C=Calcium Oxalate Dihydrate (COD) | 1 | 1.75 |
| COM+hydroxyapatite | 25 | 43.36 |
| COM=uric acid | 4 | 7.03 |
| COM=apatite | 3 | 5.27 |
| COM=struvite | 1 | 1.75 |
| Hydroxypatite+struvite | 1 | 1.75 |
| Struvite+CO | 1 | 1.75 |
| Others | 1 | 1.75 |
| TOTAL | 37 | 100 |

Conclusions
Our study has shown that indwelling time is the main risk factor for encrustation. We cannot suggest the best time when the stent must be extracted/changed and it is mainly case-dependent; however, extraction/change in the first 5 weeks will cause less complication than those that will have a bigger indwelling time. The main compound of the stent encrustation is represented by calcium oxalate that is no different from the reno/ureteral lithiasis so the pathophysiology of the stent encrustation seems to be very similar to that of the urinary lithiasis.

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