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*Original Article*

# A target-switching strategy to facilitate retroperitoneal laparoscopic partial nephrectomy for the management of large renal angiomyolipoma (≥ 6 cm)

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**Abstract:** Retroperitoneal laparoscopic partial nephrectomy has been increasingly applied to treat large renal angiomyolipoma. We hereby propose a target-switching strategy to facilitate this surgery. For this new strategy, the kidney was resected from the angiomyolipoma, rather than resecting the angiomyolipoma from the kidney. The shrunken tumor without blood supply was then taken out. Large angiomyolipoma (≥ 6 cm) patients who had retroperitoneal laparoscopic partial nephrectomy between April 2011 and May 2015 were reviewed in this study. Twenty-six patients underwent target-switching strategy. The average tumor size was 8.6±2.3 cm, and average Nephrectomy score (R.E.N.A.L score) was 7.4±1.6. Twenty-eight patients underwent traditional surgery. For these patients, the average tumor size was 8.2±2.1 cm, and average R.E.N.A.L score was 7.8±1.4. In target-switching group, shorter operation time and less blood loss were observed ($p<0.05$). The new target-switching strategy is technically feasible and may reduce operation time and blood loss. No major complication was observed in experimental group, and after one year, no tumor recurrence was observed by ultrasound or CT scan. Further randomized studies are needed to confirm our findings.

**Keywords:** Partial nephrectomy, renal angiomyolipoma, retroperitoneal surgery, target-switching strategy

## Introduction

Renal angiomyolipoma is a mesenchymal tumor of kidney, which is composed of blood vessels, smooth muscle and adipose tissue. It is often diagnosed by accident because the patients are usually asymptomatic [1]. The increased use of imaging has led to a rise in diagnosis of these lesions. The most serious and significant complication is massive retroperitoneal hemorrhage from angiomyolipoma which can be found in up to 10% of the patients [2]. Recommendations for treatment of renal angiomyolipomas are usually based on the size of the lesion and the patient's symptoms [3-5]. For large angiomyolipomas patients who require intervention, a nephron-sparing approach by either selective embolization or partial nephrectomy, is clearly preferred. Since embolization is associated with a high rate of secondary procedures [6], laparoscopic partial nephrectomy has been a preferred treatment with preservation of renal function. There are two surgical approaches of laparoscopic surgery: transperitoneal and retroperitoneal. Retroperitoneal approach is often performed in partial nephrectomy for renal angiomyolipoma. It takes shorter operating time and offers a faster recovery [7]. However, retroperitoneal space is a small artificial space created by surgeons. Additionally, large renal angiomyolipoma may bleed during surgery, making it more difficult to complete the procedure.

In this study, we describe our initial experience in regard of a target-switching strategy of retroperitoneal laparoscopic partial nephrectomy for large renal angiomyolipoma (≥ 6 cm).

## Methods

### *Inclusion and exclusion criteria*

Large angiomyolipoma patients (≥ 6 cm) who underwent laparoscopic partial nephrectomy

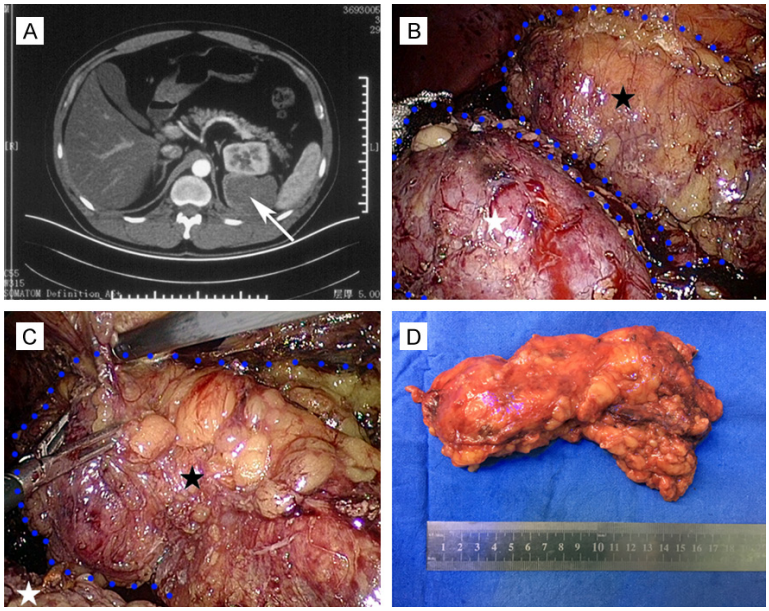


**Figure 1.** Typical case with new technique. A 35-year-old male. A left renal angiomyolipoma was diagnosed during routine physical examination. No flank pain or hematuria previously. A. CT scan of upper pole angiomyolipoma with previous bleeding. B. Renal construction completed with tumor untouched. C. Mobilization and resection of the tumor. D. Specimen. White arrow: Angiomyolipoma with previous bleeding; Black star: Angiomyolipoma; White star: Kidney after reconstruction.

between April 2011 and May 2015 in Shanghai Changhai Hospital were reviewed. Patients who received embolization or open surgery, or patients with elevated creatinine levels before surgery were excluded from this study. Twenty-six patients underwent target-switching strategy (Experimental group) while the other patients underwent traditional laparoscopic partial nephrectomy (Control group).

*Surgical techniques*

Management was the same for all patients apart from surgical strategy. All surgeries were performed by a single surgeon, who had performed over 200 partial nephrectomy cases prior to this study.

*Target-switching strategy:* After general anesthesia, patients were positioned in the full lateral decubitus position with overextension. Pneumoperitoneum was then established and trocars were placed. First of all retroperitoneal fat was mobilized and Gerota's fascia was opened. In front of the psoas muscle, renal artery was identified. The kidney was fully mobilized, and the angiomyolipoma was left untouched. Renal artery was then clamped. The kidney was resected from the angiomyolipoma without touching the tumor. After renal reconstruction, the clamp was removed. The angiomyolipoma would shrink without blood supply. Finally, the tumor was fully mobilized and taken out (**Figure 1**).

*Traditional technique:* Similarly, patients were under general anesthesia and properly positioned. Pneumoperitoneum was then established and trocars were placed. After mobilizing retroperitoneal fat and opening Gerota's fascia, renal artery was identified and clamped. The angiomyolipoma was mobilized and resected from the kidney. Then, reconstruction of the kidney was performed, and clamp was removed.

*Data collection and statistical analysis*

Patient symptoms, previous spontaneous bleeding history, tumor characteristics, operating time, warm ischemic time, estimated blood loss, and perioperative complications were recorded. The surgery is considered successful when operating time is less than 150 minutes, warm ischemic time is less than 30 minutes, bleeding is less than 200 ml, and that no conversion is needed. Influencing factors of a successful surgery were analyzed using logistic regression analysis. All patients were followed for at least a year. Ultrasound, CT scan and serum creatinine were tested. Data collection was approved by Institutional Review Board of Shanghai Changhai Hospital. All data were analyzed using SPSS version 16.0 for Windows (SPSS Inc., Chicago, IL, USA). Shapiro-Wilk test was applied to test the normality of the analyzed data. When parametric analysis was possible, the data were expressed as mean ± s.d., and independent t test was used for comparison between the 2 groups. Chi-square test was used for nonparametric analysis. $P<0.05$ was considered statistically significant.

**Table 1.** Characteristics of the patients

| | Experimental group | Control group | *P* value |
|---|---|---|---|
| n | 26 | 28 | |
| Age (year) | 48.8±8.7 | 51.4±9.4 | 0.295 |
| Body mass index (kg/m$^2$) | 24.2±3.1 | 23.6±3.8 | 0.529 |
| Sex | | | 0.743 |
| Male (n%) | 16 (61.5) | 16 (57.1) | |
| Female (%) | 10 (38.5) | 12 (42.9) | |
| Symptom | | | 0.61 |
| Asymptomatic (%) | 12 (46.2) | 11 (39.3) | |
| Symptomatic (%) | 14 (53.8) | 17 (60.7) | |
| Previous bleeding | | | 0.413 |
| Yes (%) | 2 (7.7) | 3 (10.7) | |
| No (%) | 24 (92.3) | 25 (89.3) | |
| Size (cm) | 8.6±2.3 | 8.2±2.1 | 0.507 |
| Laterality | | | 0.535 |
| Left (%) | 17 (65.4) | 16 (57.1) | |
| Right (%) | 9 (34.6) | 12 (42.9) | |
| Location | | | 0.867 |
| Upper pole (%) | 11 (42.3) | 12 (42.9) | |
| Middle pole (%) | 7 (26.9) | 9 (32.1) | |
| Lower pole (%) | 8 (30.8) | 7 (25.0) | |
| Side | | | 0.17 |
| Anterior (%) | 16 (61.5) | 12 (42.9) | |
| Posterior (%) | 10 (38.5) | 16 (57.1) | |
| R.E.N.A.L score | 7.4±1.6 | 7.8±1.4 | 0.337 |

**Table 2.** Perioperative outcomes

| | Transitional group | Control group | *P* value |
|---|---|---|---|
| N | 24 | 26 | |
| Operation time (min) | 135±42 | 166±54 | 0.023 |
| Warm ischemic time (min) | 24.7±6.2 | 27.5±7.4 | 0.134 |
| Estimated blood loss (ml) | 128±52 | 174±77 | 0.012 |
| Postoperative stay (days) | 6.7±0.5 | 6.9±0.7 | 0.235 |
| Conversion to open (%) | 0 (0) | 1 (3.8) | 1 |
| Creatinine (mmol/L) | 90.3 | 92.5 | 0.77 |

## Results

*Characteristics of patients*

Between April 2011 and May 2015, fifty-four angiomyolipoma patients (≥ 6 cm) underwent retroperitoneal laparoscopic partial nephrectomy. Twenty-six patients were in experimental group while 28 were in control group. Age, BMI, sex, spontaneous bleeding history, tumor characteristics were shown in **Table 1**, and no significant difference was noted.

*Perioperative outcomes of the 2 groups*

Perioperative parameters are shown in **Table 2**. Compared to control group, patients in experimental group had shorter operation time (p=0.023). More importantly, by using our new approach, estimated blood loss was reduced from 174 to 128 ml (p=0.012). Warm ischemic time in transpositional group was 24.7 minutes, while in control group it was 27.5 minutes (p=0.339). No major complications were observed, and all cases were completed laparoscopically except for one case in control group required conversion to the open procedure. Group, age, BMI, sex, symptom, laterality, previous bleeding, tumor size, laterality, location, side, and R.E.N.A.L score, were included into regression analysis. Group is the single factor that has significant influence on a successful surgery (**Table 3**). All renal angiomyolipoma were confirmed by pathological results.

*Follow up and clinical efficacy*

One year after surgery, no tumor recurrence was observed by ultrasound or CT scan in both groups. Serum creatinine levels were comparable between the 2 groups (p=0.77). Raw data of all patients are shown in Supplementary Table 1.

## Discussion

Renal angiomyolipoma is a benign tumor accounting for 3% of all solid kidney tumors, and it is more frequent in female than in male [8]. Tumors <4 cm are usually asymptomatic and should be followed closely. On the other hand, tumors > 4 cm are more likely to have a hemorrhagic tendency. Besides, as many as 40% patients are symptomatic, and therefore require intervention [9]. There are several treatment options to treat angiomyolipoma. Selective angioembolization is feasible and safe to reduce the risk of bleeding. Although recurrence is rare, additional treatment is sometimes necessary and life long active surveillance is needed [6, 10]. Besides, it carries a risk of non-functional kidney and hypertension.

**Table 3.** Regression analysis on a successful surgery

| | B value | S.E. | Wald | *P* value |
|---|---|---|---|---|
| Group | 1.956 | 0.819 | 5.708 | 0.017 |
| Age | 0.036 | 0.038 | 0.887 | 0.346 |
| BMI | -0.101 | 0.117 | 0.745 | 0.388 |
| Sex | 0.649 | 0.757 | 0.734 | 0.392 |
| Symptomatic | -0.621 | 0.883 | 0.495 | 0.482 |
| Previous bleeding | -21.235 | 17750.458 | 0.000 | 0.999 |
| Laterality | 0.168 | 0.710 | 0.056 | 0.813 |
| Location | 0.521 | 0.470 | 1.229 | 0.258 |
| Side | -0.961 | 0.788 | 1.485 | 0.223 |
| R.E.N.A.L score | -0.298 | 0.304 | 0.964 | 0.326 |
| Constant | 42.104 | 35500.916 | 0.000 | 0.999 |

The incidence rate of these complications can be as high as 14% to 80% [11]. The efficacy and safety of open partial nephrectomy to manage renal angiomyolipoma has been proven [12, 13]. However, a minimally invasive approach is definitely preferred in modern times to treat a benign condition. Therefore, beside all the treatments mentioned above, laparoscopic partial nephrectomy has been increasingly performed as a safe and efficient option to reduce hemorrhage [14, 15]. It allows complete tumor resection and pathological evaluation [15].

There are two surgical approaches of laparoscopic partial nephrectomy: retroperitoneal and transperitoneal approaches. Compared with transperitoneal approach, retroperitoneal laparoscopic partial nephrectomy has some obvious advantages including direct access to renal artery, shorter operating time, and hospital stay [7] and little impact on abdominal organs, which is especially helpful for patients with the history of abdominal surgeries. However, retroperitoneal space is an artificial space created by surgeons. It is small, which may increase the difficulty of the surgery [16]. In our study, all tumors were bigger than 6 cm since the prevalence of major bleeding is significantly higher [17]. Xu et al reported laparoscopic aspiration central renal angiomyolipoma [18]. It is more suitable for small turmors. Moreover, the follow-up is short and long-term outcome has to be evaluated because there may be tumor remnants. Big tumors in our study made the retroperitoneal space even more crowded. More importantly, they would easily rupture during surgery leading to major bleeding and terrible surgical view. Therefore, regular partial nephrectomy strategy may be not suitable.

For our target-switching strategy, decreased estimated blood loss and shorter operating time were observed. One of the reasons may be that kidney was excised from the angiomyolipoma instead of resecting the angiomyolipoma from the kidney. The essence of our approach is to leave the tumor untouched during tumor resection and renal reconstruction so as to prevent massive bleeding. Therefore, a clear surgical field could be provided. After renal construction, the angiomyolipoma was mobilized and resected. Since blood supply of angiomyolipoma comes from renal artery, the tumor would shrink and become soft without any blood supply. It can be easily and safely mobilized without bleeding. By applying our new technique, operating time was decreased by 18.7% (p=0.023). Additionally, estimated blood loss and was significantly decreased from 174 to 128 ml (p= 0.012). Regarding postoperative stay and warm ischemic time, the results showed no significant differences.

All cases were completed successfully except for one case in control group was converted to the open procedure. The tumor was 12 cm and was located in the middle pole close to renal hilum, with a large contact surface to the kidney. There was substantial bleeding during surgery, and we had to transfer to open nephrectomy. Renal artery embolization might have been a better choice. For these extreme cases, preoperative embolization may be helpful [19]. However, we do not recommend it as a standard procedure since the average reduction in tumor volume is only around 28% [20].

There are some limitations in this study. First of all, only a total of 54 patients were recruited, and all patients were from a single institute. Smaller differences between the 2 groups may not be detected. In our study, we did observe a decreased estimated blood loss and shorter operating time by applying our target-switching strategy. Secondly, this is a retrospective study and patients were not randomized. We started our target-switching strategy after traditional surgery. Therefore, a bias may be present. However, all cases were performed by a single surgeon who had over 200 cases of experience prior to this study, which may minimize the bias.

Further large sacle randomized controlled studies are needed to confirm our findings. Thirdly, renal function data was not collected for all patients, and patients with elevated creatinine levels before surgery were excluded.

In conclusion, our transpositional strategy may be safe and technically feasible for big exotic renal angiomyolipoma (≥ 6 cm) with retroperitoneal laparoscopic partial nephrectomy. The operation time and estimated blood loss were decreased. The new strategy may decrease the difficulty and insecurity of the surgery. Further studies are needed to confirm our study.

## Disclosure of conflict of interest

None.

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**Supplementary Table 1.** Raw data of recruited patients

| Patient No | Group (1=Experiment 2=Control) | Age | BMI | Sex (1=Male; 2=Female) | Symptomatic (1=No; 2=Yes) | Bleeding (1=Yes; 2=No) | Laterality (1=Left; 2=Right) | Location (1=Upper; 2=Middle; 3=Lower) | Side (1=Anterior; 2=Posterior) | RENAL | Operating time | WIT | EBL | Converstion (1=Yes; 2=No) | Postoperative stay | Creatinine |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 48 | 24.6 | 2 | 2 | 2 | 1 | 3 | 2 | 7 | 90 | 20 | 100 | 2 | 6 | 110 |
| 2 | 1 | 33 | 21.3 | 1 | 2 | 2 | 1 | 1 | 1 | 7 | 108 | 27 | 100 | 2 | 7 | 79 |
| 3 | 1 | 47 | 28.2 | 1 | 1 | 2 | 2 | 2 | 2 | 9 | 98 | 19 | 50 | 2 | 6 | 65 |
| 4 | 1 | 58 | 22.3 | 2 | 2 | 2 | 1 | 2 | 1 | 6 | 166 | 23 | 190 | 2 | 7 | 48 |
| 5 | 1 | 62 | 19.8 | 2 | 2 | 1 | 2 | 1 | 1 | 8 | 195 | 28 | 150 | 2 | 6 | 162 |
| 6 | 1 | 40 | 27.5 | 1 | 1 | 2 | 1 | 3 | 2 | 9 | 120 | 30 | 130 | 2 | 7 | 114 |
| 7 | 1 | 34 | 22.6 | 1 | 2 | 2 | 1 | 2 | 1 | 5 | 118 | 18 | 50 | 2 | 7 | 103 |
| 8 | 1 | 42 | 20 | 2 | 1 | 2 | 2 | 1 | 1 | 8 | 124 | 21 | 110 | 2 | 7 | 92 |
| 9 | 1 | 56 | 24.8 | 1 | 2 | 2 | 2 | 1 | 2 | 9 | 85 | 17 | 80 | 2 | 7 | 77 |
| 10 | 1 | 59 | 28.4 | 1 | 2 | 2 | 2 | 3 | 2 | 5 | 223 | 35 | 220 | 2 | 6 | 81 |
| 11 | 1 | 52 | 27.3 | 2 | 1 | 2 | 1 | 1 | 1 | 8 | 115 | 23 | 130 | 2 | 7 | 72 |
| 12 | 1 | 54 | 23.7 | 2 | 2 | 2 | 1 | 2 | 2 | 5 | 120 | 28 | 100 | 2 | 7 | 94 |
| 13 | 1 | 42 | 24.1 | 1 | 1 | 2 | 1 | 1 | 1 | 8 | 188 | 30 | 120 | 2 | 7 | 57 |
| 14 | 1 | 45 | 21 | 2 | 2 | 1 | 2 | 2 | 1 | 5 | 165 | 16 | 90 | 2 | 7 | 59 |
| 15 | 1 | 67 | 22.1 | 1 | 1 | 2 | 1 | 3 | 1 | 11 | 240 | 40 | 300 | 2 | 6 | 69 |
| 16 | 1 | 55 | 27.9 | 1 | 2 | 2 | 1 | 1 | 2 | 10 | 144 | 27 | 150 | 2 | 7 | 123 |
| 17 | 1 | 53 | 24.2 | 1 | 1 | 2 | 1 | 1 | 1 | 7 | 120 | 19 | 160 | 2 | 7 | 142 |
| 18 | 1 | 49 | 25.7 | 1 | 2 | 2 | 2 | 3 | 1 | 8 | 106 | 22 | 100 | 2 | 8 | 59 |
| 19 | 1 | 48 | 30.2 | 2 | 1 | 2 | 1 | 3 | 2 | 9 | 123 | 29 | 120 | 2 | 7 | 72 |
| 20 | 1 | 44 | 18.9 | 1 | 1 | 2 | 1 | 1 | 1 | 7 | 190 | 33 | 125 | 2 | 6 | 78 |
| 21 | 1 | 51 | 23.6 | 1 | 1 | 2 | 1 | 1 | 1 | 7 | 100 | 20 | 120 | 2 | 7 | 104 |
| 22 | 1 | 39 | 22.6 | 2 | 1 | 2 | 2 | 2 | 2 | 8 | 125 | 19 | 80 | 2 | 6 | 133 |
| 23 | 1 | 37 | 21.4 | 2 | 2 | 2 | 1 | 3 | 1 | 8 | 102 | 23 | 140 | 2 | 7 | 66 |
| 24 | 1 | 43 | 29.6 | 1 | 2 | 2 | 1 | 1 | 2 | 7 | 146 | 28 | 150 | 2 | 7 | 88 |
| 25 | 1 | 53 | 22.9 | 1 | 1 | 2 | 2 | 3 | 1 | 7 | 113 | 30 | 130 | 2 | 6 | 92 |
| 26 | 1 | 58 | 24 | 1 | 2 | 2 | 1 | 2 | 1 | 5 | 90 | 17 | 120 | 2 | 7 | 109 |
| 27 | 2 | 46 | 26.4 | 1 | 1 | 2 | 2 | 2 | 2 | 8 | 118 | 22 | 155 | 2 | 6 | 113 |
| 28 | 2 | 73 | 19.4 | 1 | 2 | 2 | 1 | 1 | 2 | 5 | 182 | 25 | 180 | 2 | 6 | 82 |
| 29 | 2 | 66 | 21.6 | 2 | 1 | 2 | 1 | 2 | 1 | 9 | 108 | 20 | 80 | 2 | 7 | 122 |
| 30 | 2 | 33 | 22 | 1 | 2 | 2 | 1 | 3 | 2 | 8 | 114 | 28 | 180 | 2 | 6 | 153 |
| 31 | 2 | 34 | 27.4 | 1 | 1 | 2 | 2 | 3 | 1 | 11 | 252 | 17 | 50 | 2 | 7 | 92 |
| 32 | 2 | 54 | 22.3 | 2 | 2 | 2 | 2 | 1 | 2 | 7 | 210 | 26 | 120 | 2 | 7 | 87 |
| 33 | 2 | 52 | 25.1 | 2 | 1 | 1 | 1 | 1 | 2 | 7 | 270 | 25 | 180 | 1 | 8 | 121 |
| 34 | 2 | 50 | 19.7 | 1 | 1 | 2 | 1 | 2 | 2 | 9 | 120 | 30 | 160 | 2 | 7 | 88 |
| 35 | 2 | 60 | 24.5 | 2 | 1 | 2 | 2 | 1 | 1 | 9 | 116 | 25 | 230 | 2 | 7 | 68 |
| 36 | 2 | 47 | 23.2 | 2 | 2 | 2 | 1 | 3 | 2 | 8 | 210 | 33 | 200 | 2 | 7 | 62 |
| 37 | 2 | 43 | 17.9 | 1 | 1 | 2 | 1 | 1 | 1 | 7 | 164 | 24 | 170 | 2 | 6 | 94 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 38 | 2 | 64 | 20 | 1 | 2 | 2 | 2 | 1 | 1 | 8 | 98 | 20 | 100 | 2 | 7 | 78 |
| 39 | 2 | 55 | 23.8 | 2 | 2 | 2 | 1 | 3 | 2 | 5 | 192 | 28 | 220 | 2 | 7 | 84 |
| 40 | 2 | 56 | 20.4 | 1 | 2 | 1 | 2 | 2 | 2 | 8 | 226 | 35 | 230 | 2 | 8 | 122 |
| 41 | 2 | 53 | 25.9 | 1 | 1 | 2 | 1 | 1 | 1 | 9 | 160 | 32 | 160 | 2 | 8 | 111 |
| 42 | 2 | 55 | 27.3 | 2 | 2 | 2 | 2 | 1 | 2 | 10 | 118 | 30 | 100 | 2 | 7 | 100 |
| 43 | 2 | 47 | 28.6 | 1 | 2 | 2 | 1 | 3 | 1 | 8 | 131 | 27 | 180 | 2 | 6 | 44 |
| 44 | 2 | 55 | 21.2 | 1 | 2 | 2 | 2 | 1 | 1 | 7 | 202 | 42 | 350 | 2 | 7 | 76 |
| 45 | 2 | 39 | 18.8 | 2 | 1 | 1 | 2 | 2 | 2 | 9 | 128 | 25 | 230 | 2 | 7 | 132 |
| 46 | 2 | 46 | 30.7 | 1 | 2 | 2 | 1 | 2 | 1 | 7 | 110 | 28 | 160 | 2 | 6 | 88 |
| 47 | 2 | 63 | 27.3 | 1 | 2 | 2 | 1 | 1 | 1 | 8 | 106 | 21 | 80 | 2 | 7 | 67 |
| 48 | 2 | 60 | 24.3 | 2 | 1 | 2 | 1 | 3 | 2 | 10 | 200 | 22 | 160 | 2 | 7 | 54 |
| 49 | 2 | 48 | 20.2 | 1 | 1 | 2 | 2 | 1 | 2 | 6 | 150 | 25 | 170 | 2 | 7 | 102 |
| 50 | 2 | 51 | 24.6 | 2 | 2 | 2 | 1 | 2 | 2 | 8 | 128 | 15 | 50 | 2 | 8 | 110 |
| 51 | 2 | 48 | 23 | 2 | 2 | 2 | 1 | 1 | 1 | 7 | 230 | 50 | 400 | 2 | 6 | 84 |
| 52 | 2 | 58 | 20.7 | 1 | 2 | 2 | 2 | 2 | 2 | 6 | 287 | 38 | 200 | 2 | 7 | 127 |
| 53 | 2 | 41 | 28.4 | 2 | 2 | 2 | 1 | 2 | 2 | 7 | 166 | 28 | 190 | 2 | 8 | 52 |
| 54 | 2 | 43 | 26.6 | 1 | 2 | 2 | 2 | 3 | 1 | 8 | 158 | 30 | 200 | 2 | 7 | 77 |