



Changes in inpatient admissions before and during COVID-19 outbreak in a large tertiary hospital in Shanghai

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Background: The coronavirus disease 2019 (COVID-19) outbreak caused a significant strain on healthcare resources and utilization worldwide. However, the impact of COVID-19 outbreak on patient hospitalization was barely known. This study aimed to determine the impact of the outbreak on the pattern of inpatient hospital admissions to help allocate health care resources during a pandemic.

Methods: This retrospective study included patients who were hospitalized in a tertiary teaching hospital in Shanghai between 1 January and 30 April across the years 2017 to 2020. The number of hospitalizations during the study period from 2017 to 2020 were 30,605, 31,464, 32,812 and 24,163, respectively. Changes in patient volumes and the frequency of the International Classification of Diseases and Related Health Problem Tenth Edition (ICD-10) codes before and after the onset of the COVID-19 outbreak were analyzed and presented as absolute and relative differences with 95% confidence intervals between periods of different years.

Results: Overall inpatient hospital admissions decreased by 26.35% between January and April 2020, compared to the same period in 2019. The average age of patients in 2020 was higher compared to those from 2017 to 2019. Conversely, the proportions of self-paying patients and non-local patients were significantly lower between January and April 2020 compared to the same period in the previous three years. The top five ICD-10 codes remained common before and during the pandemic. Admissions associated with antineoplastic radiation therapy, chemotherapy, and immunotherapy increased in frequency and proportion by 2020 (difference, 5.6%, 95% CI: 4.4% to 6.8%), and increased proportions were observed for liver and intrahepatic bile duct malignancies (2.18%, 95% CI: 1.15% to 3.21%), cerebral infarction (2.27%, 95% CI: 0.54% to 4.00%), and chronic kidney disease (3.56%, 95% CI: 1.79% to 5.33%).

Conclusions: There was a significant reduction in the number of inpatients and a marked change in admission diagnoses during the COVID-19 outbreak. Our findings are useful for making informed decisions on hospital management and reallocation of available health care resources during a pandemic.

Keywords: Coronavirus disease 2019 (COVID-19); inpatient hospital admissions; admission pattern; China

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Introduction

Coronavirus disease 2019 (COVID-19) is an infectious disease caused by the novel severe acute respiratory syndrome coronavirus 2 (SARS-COV-2) virus (1), and led to extreme and global strains on health systems and public health infrastructure. Stay-at-home orders, social distancing, and self-isolation were widely implemented to curb the transmission of this infectious disease (2).

Healthcare utilization was affected by this major public health emergency, with elective high-risk procedures and treatment for non-urgent conditions significantly cancelled or postponed (3-5). The largest decrease was seen in preventive and primary care visits for common chronic conditions (6). Importantly, previous investigations have shown that even patients with life-threatening conditions may have avoided hospital admissions, possibly due to concerns regarding exposure to the virus. Substantial reductions in admissions and treatments for cancer, stroke, and acute myocardial infarction were also reported (7-9).

In China, the utilization of inpatient and outpatient health services in medical institutions of all levels also dropped significantly after the outbreak (2). Among paediatric patients, the number of respiratory tract infections decreased in all facilities in Hunan Province, China (10), while the loss of outpatient visits in tertiary hospitals in Shanghai was greater compared to that in non-tertiary hospitals (11). In primary care settings, the decreased number of visits was related to the reappointment rate and average waiting time (12). However, few studies have examined the impact of the COVID-19 outbreak on inpatient visits and changes in diagnoses for admissions in Chinese institutions. Since medical institutions are the first line of defense against COVID-19, the pandemic poses extraordinary challenges to the health care systems in developing countries like China, which suffered from a lack of medical resources before the outbreak. Therefore, collection and analysis of health care usage during the epidemic is critical for ensuring COVID-19 preparedness and making evidence-based public health decisions.

Our study aimed to evaluate the changes in hospitalizations during the COVID-19 outbreak in our institution by comparing the counts of inpatient hospital admissions and related diagnoses during the first four months of 2020 with those during the same period from 2017 to 2019. We present the following article in accordance with the STROBE reporting checklist (available at <https://atm.amegroups.com/article/view/10.21037/atm-22-1594/rc>).

Methods

Participants

This was a retrospective observational study conducted in Ren Ji Hospital, a large tertiary teaching hospital in Shanghai, China. All inpatients admitted after the onset of the COVID-19 outbreak (1 January to 30 April 2020) were identified using the hospital's information system, while patients admitted during the same period (January 1 to April 30) in the previous three years (2017, 2018, and 2019) were selected as controls. The number of inpatients during the study period determined the sample size. The discharge summary data were retrieved for each inpatient along with demographics (age, sex, residence address, and payment), discharge diagnosis, ICD-10 codes, and length of stay in days (LOS). Those who lacked admission and discharge dates, age, sex, discharge diagnosis, or ICD-10 code were excluded and each hospitalization record was considered as an independent event. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). All data were properly anonymized and no specific patients were involved; thus, the consent from patients and the ethical approval was waived by the ethics committee of Ren Ji Hospital.

Measurements

The main outcomes of the study were the changes in the number of inpatient hospital admissions and diagnoses. The number of admissions was described for the outbreak period and the corresponding periods in the previous three years. The diagnoses were grouped according to ICD-10 codes, and changes in the outcomes were presented as absolute and relative differences between the periods. The way of payment was divided into self-pay or others, and the residence was defined as either local or non-local.

Statistical analysis

Patient demographic and clinical characteristics were summarized by period. Continuous variables were summarized as mean or median (first and third quartiles), while categorical variables were summarized as counts (percentages, %). Differences in patient characteristics between the years were compared using chi-square tests and one-way analysis of variance, and multiple testing was performed using the false discovery rate method. The Cochran-Armitage test was used to detect trends in

Table 1 Characteristics of inpatients included in this study

Variables	2017 (N=30,605)	2018 (N=31,464)	2019 (N=32,812)	2020 (N=24,163)	P value
Sex					<0.001
Male	14,732 (48.14) ^a	15,346 (48.77) ^a	16,428 (50.07) ^b	12,524 (51.83) ^c	
Female	15,873 (51.86)	16,118 (51.23)	16,384 (49.93)	11,639 (48.17)	
Age (years), mean (SD)	53.2 (17.8) ^a	53.3 (18.0) ^a	54.1 (17.6) ^b	55.8 (16.9) ^c	<0.001
<10	467 (1.53)	506 (1.61)	494 (1.51)	286 (1.18)	<0.001
11–20	510 (1.67)	562 (1.79)	615 (1.87)	307 (1.27)	
21–30	3,090 (10.10)	3,076 (9.78)	2,635 (8.03)	1,571 (6.50)	
31–40	3,979 (13.00)	4,251 (13.51)	4,294 (13.09)	2,821 (11.67)	
41–50	3,695 (12.07)	3,712 (11.80)	4,064 (12.39)	2,981 (12.34)	
51–60	6,439 (21.04)	6,057 (19.25)	6,294 (19.18)	4,833 (20.00)	
61–70	7,992 (26.12)	8,494 (27.00)	9,141 (27.86)	7,248 (30.00)	
71–80	3,145 (10.28)	3,523 (11.20)	3,988 (12.15)	3,102 (12.84)	
>80	1285 (4.20)	1283 (4.08)	1285 (3.92)	1014 (4.20)	
Payment					
Self-pay	11,990 (39.18) ^a	11,133 (35.38) ^b	9,265 (28.24) ^c	4,902 (20.29) ^d	<0.001
Others	18,615 (60.82)	20,331 (64.62)	23,547 (71.76)	19,261 (79.71)	
Residence					<0.001
Local	17,494 (57.16) ^a	17,669 (56.16) ^b	17,999 (54.85) ^c	14,602 (60.43) ^d	
Non-local	13,111 (42.84)	13,795 (43.84)	14,813 (45.15)	9,561 (39.57)	
Length of stay (LOS), mean (SD)	5.8 (8.9) ^a	5.6 (8.5) ^b	5.6 (8.4) ^b	5.9 (9.3) ^a	0.004

^{a-d}, letters indicate statistically significant differences between groups. For groups with the same letter, the difference between the means is not statistically significant. For groups with different letters, they are significantly different.

proportions. R version 4.0.1 (R Foundation for Statistical Computing, Vienna, Austria) was used for all statistical analyses, and the statistical significance was set for a two-sided $P < 0.05$.

Results

Patient characteristics

A total of 119,044 inpatients were identified during the study period and their demographic characteristics are summarized in *Table 1*. The number of admissions increased by 7.2%, from 30,605 in 2017 to 32,812 in 2019, and in contrast, there were only 24,163 admissions in 2020, a decrease of 26.35% compared to 2019. There was a significant increase in the proportion of males from 2017 to 2020 ($P < 0.001$), and pairwise comparisons showed that in 2020 this was

higher compared to the previous three years. The mean ages of patients from 2017 to 2020 was 53.2 (± 17.8), 53.3 (± 18.0), 54.1 (± 17.6), and 55.8 (± 16.9) years, respectively. Additionally, there was a significant difference among different years ($P < 0.001$) and the average age of patients in 2020 was higher compared to that from 2017 to 2019.

The proportion of self-paying patients decreased annually ($P < 0.001$) with the proportion of local patients (60.43%) in 2020 being significantly higher compared to the previous three years ($P < 0.001$). The LOS in 2020 was significantly longer compared to the previous two years (5.9 days vs. 5.6 in both 2018 and 2019).

Changes in the number of inpatient admissions grouped by ICD-10 chapters

The yearly number of inpatient hospital admissions

Table 2 Comparison of the inpatient hospital admissions grouped by ICD chapters

ICD-10 chapters	2017		2018			2019			2020		
	No.	Rank	No.	Rank	% change	No.	Rank	% change	No.	Rank	% change
21. Factors influencing health status and contact with health services	7,310	1	7,983	1	9.21	7,969	1	-0.18	7,599	1	-4.64
2. Neoplasms	5,300	2	5,522	2	4.19	6,104	2	10.54	4,577	2	-25.02
14. Diseases of the genitourinary system	3,883	3	4,120	3	6.10	3,322	5	-19.37	2,378	3	-28.42
9. Diseases of the circulatory system	3,175	4	3,108	4	-2.11	3,472	3	11.71	2,246	4	-35.31
11. Diseases of the digestive system	3,050	5	3,081	5	1.02	3,372	4	9.44	2,127	5	-36.92
13. Diseases of the musculoskeletal system	1,682	6	1,740	6	3.45	1,906	6	9.54	1,295	6	-32.06
15. Pregnancy, childbirth, and the puerperium	1,275	7	1,149	7	-9.88	1,240	7	7.92	1,006	7	-18.87
7. Diseases of the eye and adnexa	1,002	8	797	8	-20.46	876	8	9.91	452	9	-48.40
10. Diseases of the respiratory system	751	9	741	9	-1.33	823	9	11.07	381	10	-53.71
19. Injury, poisoning, and external causes	671	10	733	10	9.24	783	10	6.82	669	8	-14.56
17. Congenital malformations	569	11	401	12	-29.53	450	12	12.22	263	12	-41.56
4. Endocrine, nutritional, and metabolic diseases	553	12	652	11	17.90	651	11	-0.15	344	11	-47.16
6. Diseases of the nervous system	361	13	392	13	8.59	425	14	8.42	173	14	-59.29
18. Symptoms, signs, and abnormal findings	278	14	244	15	-12.23	445	13	82.38	206	13	-53.71
12. Diseases of the skin and subcutaneous tissue	243	15	245	14	0.82	349	15	42.45	128	16	-63.32
1. Certain infectious and parasitic diseases	165	16	185	16	12.12	198	17	7.03	123	17	-37.88
3. Diseases of the blood and blood-forming organs	147	17	136	17	-7.48	123	18	-9.56	131	15	6.50
5. Mental and behavioral disorders	104	18	162	18	55.77	200	16	23.46	29	18	-85.50
8. Diseases of the ear and mastoid process	86	19	73	19	-15.12	103	19	41.10	36	19	-65.05

ICD, International Classification of Diseases and Related Health Problem.

grouped by ICD-10 disease chapters is shown in *Table 2*. In 2018 and 2019, compared with 2017, the number of inpatient admissions for most ICD chapters increased. In contrast, the number of admissions for most ICD chapters decreased in 2020, except for a 6.50% increase in Chapter 3

‘diseases of the blood and blood-forming organs’. In 2020, the highest decrease in admissions was associated with chapters 5 ‘mental and behavioural disorders’ (-85.50%), 8 ‘diseases of the ear and mastoid process’ (-65.05%), 12 ‘diseases of the skin and subcutaneous tissue’ (-63.32%), 6

‘diseases of the nervous system’ (−59.29%), and 10 ‘diseases of the respiratory system’ (−53.71%).

Changes in the ranks of ICD-10 chapters

We found differences in the proportion and ranking of the ICD-10 chapters after the COVID-19 outbreak in 2020 (Table 2). The top five ICD-10 chapters in 2017 were chapters 21 ‘factors influencing health status and contact with health services’, 2 ‘neoplasms’, 14 ‘diseases of the genitourinary system’, 9 ‘diseases of the circulatory system’, and 11 ‘diseases of the digestive system’, which remained the most frequently listed diagnostic area before and during the outbreak. The proportion of Chapter 21 increased from 24.29% in 2019 to 31.45% in 2020, while the proportions of chapters 14, 9, and 11 dropped in 2020. Chapter 19 ‘injury, poisoning and external causes’ ranked tenth pre-outbreak but rose to the eighth place during the outbreak in 2020.

Changes in admissions by ICD-10 chapters

To further analyze adaption to the restricted resources associated with the COVID-19 pandemic, we examined changes in the diagnostic codes of the top five ICD chapters (Table 3). The number of admissions related to disease code Z09 (follow-up examination for conditions other than malignant neoplasm) was reduced by 77.56% from 2019 to 2020. Z09 and Z08 (follow-up examination for malignant neoplasm) were significantly decreased in 2020, while Z51 (antineoplastic radiation therapy, chemotherapy, and immunotherapy) was significantly increased (difference, 5.6%, 95% CI: 4.4–6.8%). The proportion of code C61 decreased significantly in 2020 (difference, −1.54%, 95% CI: −2.46% to −0.62%), while the proportion of C22 increased from 6.54% in 2019 to 8.72% (difference, 2.18%, 95% CI: 1.15% to 3.21%). All admissions related to the top five ICD codes in Chapter 14 ‘diseases of the genitourinary system’ decreased in 2020. The proportions of code N20 (calculus of kidney and ureter), N47 (disorders of prepuce), and N05 (unspecified nephritic syndrome) decreased significantly, while the proportion of N18 increased (difference, 3.56%, 95% CI: 1.79% to 5.33%).

Among the circulatory system diseases, there were marked reductions in admission related to the top five codes in 2020. The proportions of code I24 (other acute ischaemic heart diseases), I48 (atrial fibrillation and flutter), and I87 (other disorders of veins) decreased in 2020, while

the proportion of I63 (cerebral infarction) increased from 10.69% in 2019 to 12.96% in 2020 (difference, 2.27%, 95% CI: 0.54–4.00%). Of digestive system diseases, admissions related to all top five ICD codes decreased in 2020. The proportions of code K50 (Crohn’s disease), K74 (fibrosis and cirrhosis of the liver), and K75 (other inflammatory liver diseases) also decreased in 2020.

Discussion

Using data from a large tertiary teaching hospital in Shanghai, we found marked changes in the number of inpatient admissions and the frequency of ICD-10 codes between January and April 2020, compared with the same period in the preceding years. In contrast, a slight increase of 4.28% was observed from 2018 to 2019. A reduction in healthcare utilization during the COVID-19 lockdown was also observed in Germany (13), Italy (14), Korea (15), the UK (8), and the USA (16). The reasons for the decline in inpatient admissions are likely to be multifactorial. One hypothesis is that patients were reluctant to attend hospitals due to fear of contracting COVID-19, which could account for the reduction in the overall admissions and increased LOS during this period. Moreover, China employed large-scale travel restrictions to mitigate the pandemic. Intercity travel restrictions were more likely to prevent patients from rural and underdeveloped areas from seeking medical services in medical institutions in more developed areas, as evidenced by the substantial reduction in self-paying and non-local patients post COVID-19. The loss of inpatient admissions could be partially explained by the implementation of hierarchical medical care during the outbreak to avoid crowds in tertiary hospitals.

Despite a quarter decrease in the number of inpatients, the top five ICD-10 chapters remained the most common in both before and during the outbreak. Importantly, the proportion of chapters 21 and 2 ‘neoplasms’ increased, while most of the remaining chapters decreased. In Chapter 21, the most frequent code was ‘antineoplastic radiation therapy, chemotherapy, and immunotherapy’, which suggested most patients were hospitalized for cancer treatment. The top five chapters were consistent with the main causes of death of urban residents based on the 2019 China Statistical Yearbook, with malignancies being the leading cause, followed by heart disease, cerebrovascular disease, and respiratory disease. This highlights the need to continue providing medical services for patients suffering from these diseases during emergencies.

Table 3 Changes in inpatient admissions in 2020 compared to 2019

Code	2019	2020	Relative change in no. of admission	Difference in proportion (95% CI)
Factors influencing health status and contact with health services				
Z51, antineoplastic radiation therapy, chemotherapy, and immunotherapy	6,315 (79.24)	6,447 (84.84)	2.09	5.60 (4.40 to 6.80)
Z43, attention to artificial openings	316 (3.97)	336 (4.42)	6.33	0.45 (−0.18 to 1.08)
Z08, follow-up examination for malignant neoplasm	286 (3.59)	171 (2.25)	−40.21	−1.34 (−1.87 to −0.81)
Z09, follow-up examination for conditions other than malignant neoplasm	223 (2.80)	50 (0.66)	−77.58	−2.14 (−2.55 to −1.73)
Z45, adjustment and management of implanted device	155 (1.95)	151 (1.99)	−2.58	0.04 (−0.40 to 0.48)
Neoplasms				
C16, malignant neoplasm of stomach	457 (7.49)	310 (6.77)	−32.17	−0.72 (−1.70 to 0.26)
C61, malignant neoplasm of prostate	425 (6.96)	248 (5.42)	−41.65	−1.54 (−2.46 to −0.62)
C22, malignant neoplasm of liver and intrahepatic bile ducts	399 (6.54)	399 (8.72)	0.00	2.18 (1.15 to 3.21)
C34, malignant neoplasm of bronchus and lung	375 (6.14)	321 (7.01)	−14.40	0.87 (−0.08 to 1.82)
C67, malignant neoplasm of bladder	357 (5.85)	292 (6.38)	−18.21	0.53 (−0.39 to 1.45)
Diseases of the genitourinary system				
N20, calculus of kidney and ureter	595 (17.91)	379 (15.94)	−36.30	−1.97 (−3.94 to 0)
N18, chronic kidney disease	365 (10.99)	346 (14.55)	−5.21	3.56 (1.79 to 5.33)
N40, benign prostatic hyperplasia	325 (9.78)	231 (9.71)	−28.92	−0.07 (−1.63 to 1.49)
N47, disorders of prepuce	198 (5.96)	40 (1.68)	−79.80	−4.28 (−5.24 to −3.32)
N05, unspecified nephritic syndrome	177 (5.33)	93 (3.91)	−47.46	−1.42 (−2.51 to −0.33)
Diseases of the circulatory system				
I25, chronic ischemic heart disease	745 (21.46)	437 (19.46)	−41.34	−2.00 (−4.13 to 0.13)
I24, other acute ischemic heart diseases	378 (10.89)	53 (2.36)	−85.98	−8.53 (−9.74 to −7.32)
I63, cerebral infarction	371 (10.69)	291 (12.96)	−21.56	2.27 (0.54 to 4.00)
I48, atrial fibrillation and flutter	187 (5.39)	81 (3.61)	−56.68	−1.78 (−2.86 to −0.70)
I87, other disorders of veins	180 (5.18)	72 (3.21)	−60.00	−1.97 (−3.01 to −0.93)
Diseases of the digestive system				
K50, Crohn's disease	728 (21.59)	396 (18.62)	−45.60	−2.97 (−5.13 to −0.81)
K80, cholelithiasis	501 (14.86)	333 (15.66)	−33.53	0.80 (−1.16 to 2.76)
K74, fibrosis and cirrhosis of liver	262 (7.77)	130 (6.11)	−50.38	−1.66 (−3.02 to −0.30)
K75, other inflammatory liver diseases	242 (7.18)	73 (3.43)	−69.83	−3.75 (−4.92 to −2.58)
K40, inguinal hernia	194 (5.75)	111 (5.22)	−42.78	−0.53 (−1.76 to 0.70)

Our results regarding Chapter 21 admissions showed antineoplastic radiation therapy, chemotherapy, and immunotherapy increased in frequency and proportion in 2020. In comparison, admissions related to non-malignant conditions decreased dramatically. Concurrently, reduced neoplasms were less pronounced compared to most of the remaining chapters. In particular, the number of patients with liver and intrahepatic bile duct malignancies remained unchanged, although the proportion increased. These results illustrate the careful prioritization of cancer patients due to the time-sensitive nature of the evaluation and continued treatment of malignancies. Similarly, the number of cancer patients seeking traditional Chinese medicine treatment increased by approximately 50% during the COVID-19 outbreak in Taiwan, China (17). The observed trend regarding admissions due to cancer care during the outbreak is consistent with reports from Brazil (18) and the UK (8). Previous evidence has shown that a decrease in cancer patients seeking treatment may have negative effects on their survival and mortality in the near future (19). Therefore, more research is required to understand how the COVID-19 outbreak affects the prognosis of cancer.

Overall, the top five codes of circulatory system diseases significantly decreased in frequency. This reduction was consistent with previous studies that showed underutilization of health care in emergencies of this system such as acute ischaemic stroke and myocardial infarction during the COVID-19 outbreak (7,13,20). Of note, our findings showed the lowest decrease was in the number of admissions due to cerebral infarction, and its proportion was higher compared to the same period in 2019. Wosik *et al.* found a decline of 33.1% in the number of outpatient cardiology visits in the Duke University Health System between 15 March to 30 June 2020 compared with the same period in 2019 (21). The COVID-19 outbreak has led to a significant reduction in hospitalization rates for acute myocardial infarction in northern Italy (14), France (22), and Northern California, USA (9). Among medical insurance beneficiaries in the United States, a decrease in the number of patients with stroke was observed, which remained at a lower level than usual (16). Public health agencies should play an active role in reminding the public of the signs of stroke and encouraging them to seek immediate medical care to reduce serious outcomes.

Among the top five diseases of the genitourinary system, the least reduction was observed for chronic kidney disease, while the strongest decrease was for disorders of the

prepuce. Concurrently, the number of hospitalizations for the top five diseases of the digestive system fell by more than one-third. Decreased disease in the genitourinary system and digestive systems in 2020 may be related to the fact that patients chose to seek medical treatment closer, delayed visits, or undertook telemedicine during the pandemic. While the COVID-19 outbreak led to an increase in the use of telemedicine and virtual care (21,23-25), our analysis did not capture its trend. Thus, further studies are required to assess the use of telehealth visits and changes in care-seeking behaviours during the pandemic.

This study has several limitations. First, this was a retrospective analysis, and we may not have collected all the potential confounding variables to account for the changes in inpatient admissions. Second, although our hospital is the largest comprehensive tertiary hospital in Pudong New Area of Shanghai, this study was based on a single-center, and the results may not be widely generalizable to other hospitals and regions in China. Results of a nationally representative analysis showed that the reduction in healthcare utilization was greater in more developed regions and higher-level health facilities (2). Third, we did not have information on the reasons for postponed or cancelled admissions initiated by patients or based on patient-centered judgement. Therefore, further research is required to determine how these medical decisions were made. Additionally, the long-term effects of the pandemic could be investigated using predictive models. Conversely, the strength of this study was the large number of inpatient admissions and ICD-10 codes analyzed for all chapters.

Conclusions

Our study showed the volume of inpatient hospital admissions was significantly reduced following the COVID-19 outbreak compared to the same period in the preceding three years. Notably, admissions for cancer treatment decreased in number but accounted for a larger proportion of the total admission volume. A better understanding of these differences could help correctly redistribute available resources to provide medical care during a pandemic.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at <https://atm.amegroups.com/article/view/10.21037/atm-22-1594/rc>

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at <https://atm.amegroups.com/article/view/10.21037/atm-22-1594/coif>). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). All data were properly anonymized and no specific patients were involved; thus, the consent from patients and the ethical approval was waived by the ethics committee of Ren Ji Hospital.

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