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Original Contribution

# Clinical characteristics of elderly drowning patients

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ABSTRACT

*Purpose:* Drowning is one of the major causes of traumatic death. The impact of drowning in the elderly and patients who were not elderly will be different because of physiological differences. We wanted to analyze the clinical differences such as mortality, incidence rate of complications, degree of hypothermia and rate of cardiac arrest between elderly and adult drowning patients.

*Methods:* This study included drowning patients over 18 years old who came to an emergency department (ED) located on a riverside from September 1997 to July 2016. Patients over the age of 65 years were classified as elderly, while those under the age of 65 years were classified as adults. Demographic data and clinical outcomes were surveyed.

*Results:* A total of 611 patients were included in this study. Sixty-one patients (9.9%) were elderly, and 550 patients (90.1%) were adults. There were 17 elderly patients (15.8%) and 87 adult patients (27.9%) who had cardiac arrest at the time of ED arrival ($p = 0.017$). The rate of body temperatures < 34 °C was higher in elderly patients than that in adult patients (27.9% vs 17.5%, respectively, $p = 0.025$). The rates of hospitalization in the intensive care unit (ICU) and mortality were higher in elderly group (23% vs. 15.1%, respectively, $p = 0.01$; 37.7% vs 21.8%, respectively, $p = 0.01$). There was no significant difference in suicidal intent between the elderly and adult patient groups (82.0% vs 78.9%, respectively, $p = 0.421$).

*Conclusions:* Elderly drowning patients accounted for approximately 1/10 of all drowning cases and were more likely to experience a cardiac arrest, hypothermia, mortality, and ICU admission.



## 1. Introduction

Death by drowning is the third most common cause of death from unintentional injury death in the world and accounts for 7% of all injury-related deaths. Approximately 360,000 people die annually by drowning worldwide, making it the most common cause of death by preventable unintentional trauma. [1]

According to the Statistics Korea, a total of 38,267 people has died by drowning from 1991 to 2010 in South Korea, with an average of 1913 deaths a year. According to the statistics from 2016, the number of deaths due to drowning was 4.1 per 100,000 people in the world, 1.3 per 100,000 in the US, 5.84 per 100,000 in the developing world, and 1.81 per 100,000 in the Republic of Korea. [2] The number of deaths due to drowning decreased from 4.3/100,000 in 1991 to 1.3/100,000 in 2010, but deaths due to intentional drowning such as suicide gradually increased from 7.3/100,000 in 1991 to 25.6/100,000 in 2010. [3,4]

The largest number of drowning in Korea occurred in the Han River in Seoul. Most of the drownings in this study occurred from a bridge. The mean height from the bridge to the surface of the Han River is 17.9 m in dry season and 14.7 m in wet season [5]. As the number of people that enjoy aquatic leisure activities has increased, there is now more unintentional drowning than intentional drowning. [3] However, recent studies have shown that intentional drowning occur more frequently as people get older and use alcohol or drugs. [6]

Korea is now an aging society. People over the age of 65 years accounted for 13.1% of the total population in 2015, with future estimated increases up to 19% in 2024 and 27.6% in 2034, thus representing the fastest growing elderly population in the world. [7] As the importance of elderly patient increases, studies analyzing senile disease and the characteristics of elderly patients are actively under way. Differentiated care is necessary in elderly people since they have different epidemiological reasons to drown, physiological mechanisms and clinical characteristics compared with those of adults. [8] Further, as age increases, there is an increase in possible senile depression and suicide attempts. Therefore, we may suppose that the frequency of intentional drowning in the elderly will increase as the proportion of the elderly population increases. [9]

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There are many studies on the clinical characteristics and treatment methods of drowning patients. However, studies on the characteristics of drowning patients based on age are very rare; therefore, further studies in this area are needed. [10]

Therefore, this study would like to propose cues and directions for prevention and treatment of drowning in the elderly population by comparing and analyzing the drowning epidemiological profile and clinical characteristics of the elderly and adults.

## 2. Materials and methods

This is a retrospective, observational study conducted at one hospital in Seoul after receiving approval from the International Review Board of the hospital. This hospital is a general teaching hospital with approximately 35,000 emergency department (ED) visits per year. As it is located on the side of the Han River, which is the largest river in South Korea, patients frequently visit this hospital after drowning. From September 1997 to July 2016, we included all drowning patients except for those younger than 18 years old or those with missing records.

The rescue and basic resuscitation of drowning patients through the EMS and advanced resuscitation after the arrival to the emergency department followed the guidelines of the most recent AHA Guideline at the time [11]. The EMS immediately performs CPR when the patient is found unconscious, pulseless or breathless upon their arrival at the scene. The indication for invasive airway after arrival was GCS 8 or less or PaO2/FiO2 < 200 mmHg at the time of arrival and according to the clinician's decision.

Data were collected from the patients' medical records and reviewed retrospectively. Epidemiological characteristics that were surveyed retrospectively included gender, season, time of event, intention, place, drowning duration, underlying diseases, and history of a prior suicide attempt. Clinical characteristics also were surveyed included cardiac arrest at the scene, vital signs, mental status, the need for invasive ventilation, treatment results in the ED, intensive care unit (ICU) admission, and treatment outcome results after hospitalization. At the time of ED arrival, each patient's body temperature was checked using a tympanic thermometer; when the tympanic thermometer read 'low', the patients' body temperature was re-checked using a rectal thermometer. The measured body temperature was divided into 2 degrees within the range of >36° to <30° according to the temperature. The seasonal mean temperature and mean body temperature were compared. Patients were classified into an adult group if they were aged 18 to 65 years, and an elderly group if they were aged 65 years or older. [12]

Statistical analysis was performed with PASW statistics ver. 18.0 (SPSS Inc., Chicago, USA). Normality was tested using the Kolmogorov-Smirnov test, and categorical variables were expressed as frequencies and percentages, Chi-squared or Fisher's exact tests were used to compare the two groups. In cases of normal distributions, the mean values were compared using a *t*-test, while in cases of non-normal distributions, the median values were compared using the Mann-Whitney test. A p-value of <0.05 was considered statistically significant.

## 3. Results

### 3.1. Demographic comparison between the two groups

During the study period, a total of 675 patients visited the ED with a chief complaint of drowning. Sixty-four patients were excluded because they were aged under 18 years or were missing medical records. A total of 611 patients were included in this study, with 61 patients (9.9%) in the elderly group and 550 patients (90.1%) in the adult group, yielding a ratio of 1: 9. (Fig. 1).

Drownings as suicidal intention accounted for 50 (82.0%) and 434 patients (78.9%) in the elderly and adult groups, respectively ($p = 0.421$). There were 28 (45.9%) male patients in the elderly group and 320 (58.2%) in the adult group, with no significant differences between the two groups ($p = 0.066$). Drowning occurred most frequently in the summer in both groups (39.3% vs 34.7%, $p = 0.865$). In the elderly group, drowning events occurred most commonly between 12:00 and 18:00 (27 patients, 44.3%), while in the adult group, drowning events occurred at relatively equal rates at all times of day ($p < 0.001$). Drownings in the elderly group occurred in 43 patients (70.5%) after jumping from a bridge, 13 (21.3%) by walking from the riverside, 2 (3.3%) while in the bathtub and 3 (4.9%) while in the swimming pool. In the adult group, 468 patients (85.1%) jumped from a bridge, 76 (13.8%) walked from the riverside, 3 (0.5%) drowned in the bathtub and 3 (0.5%) drowned in the swimming pool ($p = 0.001$). Use of alcohol before the drowning event was noted in 6 patients (9.8%) in the elderly group and 174 patients (31.6%) in the adult group, with a significantly higher rate in the adult group ($p = 0.001$). The estimated drowning duration was a little longer in elderly group, but there was no statistical difference ($17.3 \pm 23.4$ min vs $15 \pm 20.5$ min, $p = 0.561$) (Table 1).

### 3.2. Comparing baseline medical conditions of drowning patients between the elderly and adult drowning groups

The prevalence of chronic diseases such as diabetes, hypertension and hepatitis were significantly higher in elderly patients compared to adult patients, with 15 elderly patients (24.6%) and 18 adult patients (3.3%) affected ($p < 0.001$). There were no significant differences between the two groups in the diagnosis of psychiatric disorders such as depression ($p = 0.810$), mental retardation, schizophrenia, anxiety disorder and panic disorder ($p = 0.198$). There was no significant difference in the rates of previous suicide attempts between the two groups ($p = 0.518$) (Table 2).

### 3.3. Comparing clinical characteristics between the two groups in the ED

17 patients (27.9%) in the elderly group and 87 patients (15.9%) in the adult group were in cardiac arrest at the time of ED arrival regardless of whether BLS was provided in EMS, which showed the elderly group had a higher rate of cardiac arrest ($p = 0.017$). The total number of deaths in the ED, including at the time of ED arrival and after ED treatment, was 23 patients (37.7%) in the elderly group and 120 patients (21.8%) in the adult group, which also showed a higher mortality rate in the elderly group ($p = 0.01$). Elderly drowning patients were in a worsened mental state, which was stupor to comatose mentality, at the time of ED arrival compared to that of adult patients (50.8% vs 33.8%, respectively, $p = 0.015$). However, in both group, mental status was coma immediately after ROSC. Among the elderly patients, there was 1 survival from cardiac arrest, while there were 15 survivals in the adult group. Among the 15 survivals in the adult group, 4 cases are cerebral performance category (CPC) 1 and 11 cases are CPC 4, while the lone survival from the elderly group is CPC 4. Invasive ventilation was more needed in the elderly group than in the adult group (26.2% vs 15.6%, $p = 0.035$). Elderly drowning patients were more likely to have hypothermia at the time of ED arrival; 17 patients (27.9%) in the elderly group had body temperatures below 34 °C compared with 96 patients (17.5%) in the adult group ($p = 0.025$); however, the most common temperature range in both groups was from 34 to 36 °C (47.5% vs 44.4%, respectively). Seasonal mean temperature of Seoul in Korea was 12 °C in spring, 24.2 °C in summer, 14.4 °C in autumn, and 0.5 °C in winter. The average temperature of all patients in spring, summer, autumn and winter was 36.3 °C, 35.26 °C, 34.85 °C and 33.26 °C. [13]

After ED treatment, the discharge to home rate was lower in the elderly group compared with that of the adult group (29.5% vs 47.8%). The ICU admission rate was higher in the elderly group (23.0% vs 15.1%) (Table 3).

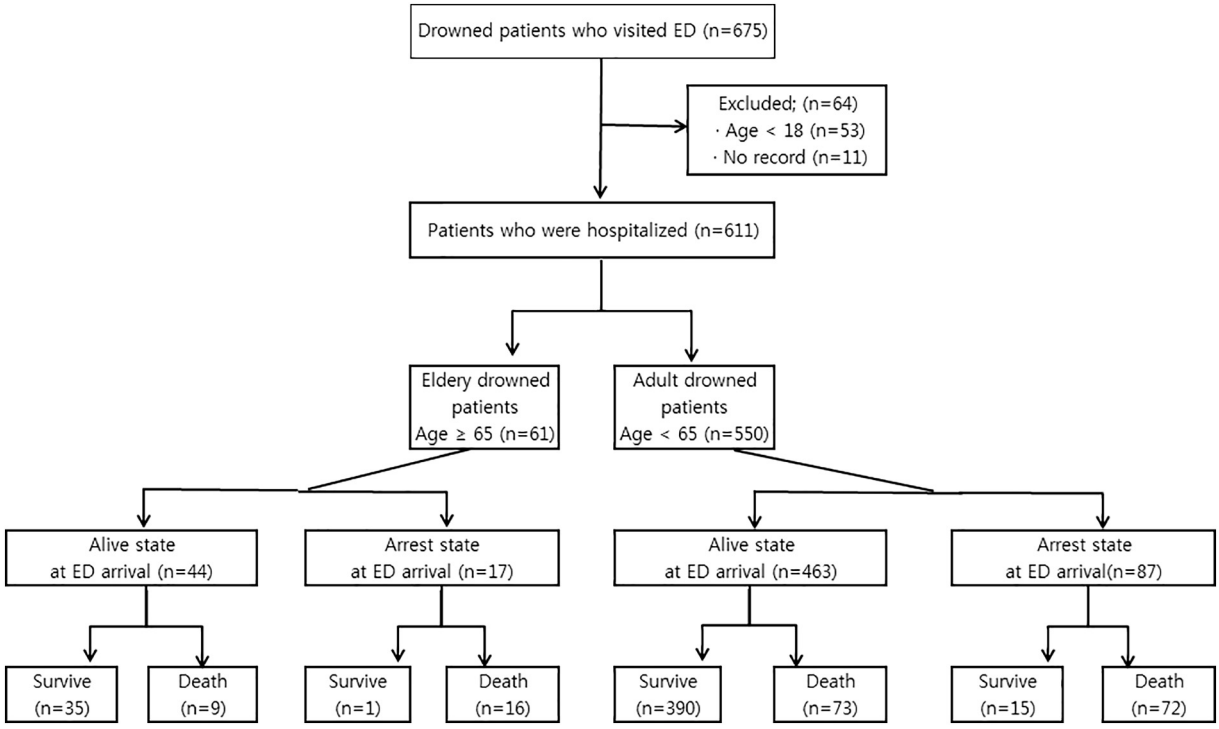


**Fig. 1.** Flow chart showing the patient enrollment.

## 4. Discussion

Drowning is a series of processes that cause respiratory impairment due to fluid aspiration. [14] There are two major clinical aspects of drowning. First, aspiration of water causes hypoxemia, and that leads to hypoxic encephalopathy and arrhythmia. Second, due to the liquid entering the lungs, the alveoli are damaged by the osmotic pressure difference between the alveoli and the inflowing liquid, causing lung hypoventilation and sequelae such as atelectasis and pulmonary edema. [15-17]

Compared with healthy adults, the internal organs of the elderly have several distinct characteristics. First, the elderly has a reduced functional capacity. [18-20] Second, they possess a reduced ability to cope with challenges. [21] Third, they have altered homeostasis. [22,23] Unlike the lungs of adults, the lungs of the elderly undergo structural and functional changes, and have weaker immune system because the mucosal layer collapses and decreases the ability for mucosal cilia to remove pathogens. [24] Therefore, in the same environment, the elderly is more likely to develop respiratory diseases after drowning than are adults. From these physiologic differences, this study showed that the need to create an invasive airway was significantly higher in elderly patients than that in adult patients (26.2% vs 15.6%, p = 0.035) and that both cardiac arrest state on ED arrival (27.9% vs 15.9%, p = 0.017) and mortality after ED treatment (37.7% vs 21.8%, p = 0.01) were significantly higher in the elderly than in adults. The rate of ICU admission was also much higher in elderly patients than in adult patients (23.0% vs 15.1%, p = 0.01).

In this study, the body temperature of elderly patients on ED arrival was significantly lower than that of the adult patients. Body temperature is controlled through the interaction between thermal sensors, neural pathways and effectors. In the elderly, thermoregulatory system defects occur at various stages to reduce their ability to sense hot and cold, resulting in decreased heat generation and dissipation in high

**Table 1**
A comparison of the general characteristics of drowning patients between elderly group and adult group.

| | Elderly (n = 61) | Adult (n = 550) | p |
|---|---|---|---|
| Age (year)[a] | 72 (68.5–76.5) | 31.5 (23.7–43.0) | |
| Sex (n, %) | | | 0.066 |
| Male | 28 (45.9) | 320 (58.2) | |
| Season (n, %) | | | 0.865 |
| Spring | 14 (23.0) | 149 (27.1) | |
| Summer | 24 (39.3) | 191 (34.7) | |
| Fall | 13 (21.3) | 115 (20.9) | |
| Winter | 10 (16.4) | 94 (17.1) | |
| Onset/Time (n, %) | | | <0.001 |
| 00:00–06:00 | 6 (9.8) | 159 (28.9) | |
| 06:00–12:00 | 14 (23.0) | 89 (16.2) | |
| 12:00–18:00 | 27 (44.3) | 137 (24.9) | |
| 18:00–24:00 | 9 (14.8) | 120 (21.8) | |
| Cause of drowning (n, %) | | | 0.421 |
| Intentionally | 50 (82.0) | 434 (78.9) | |
| Non-intentionally | 9 (14.8) | 106 (19.3) | |
| Unknown | 2 (3.3) | 10 (1.8) | |
| Place of drowning (n, %) | | | 0.001 |
| Jump from bridge | 43 (70.5) | 468 (85.1) | |
| Walk from riverside | 13 (21.3) | 76 (13.8) | |
| Bath | 2 (3.3) | 3 (0.5) | |
| Swimming pool | 3 (4.9) | 3 (0.5) | |
| Alcohol ingestion (n, %) | 6 (9.8) | 174 (31.6) | 0.001 |
| Immersion duration (min) | 17.3 ± 23.4 | 15 ± 20.5 | 0.561 |

SD, standard deviation.
[a] Median value with interquartile range.

**Table 2**
A comparison of the baseline medical condition of drowning patients between elderly group and adult group.

| | Elderly (n = 61) | Adult (n = 550) | p |
|---|---|---|---|
| Systemic underlying disease[a] (%) | 15 (24.6) | 18 (3.3) | <0.001 |
| Major depressive disorder (%) | 6 (9.8) | 49 (8.9) | 0.81 |
| Psychotic disorder[b] (%) | 1 (1.6) | 30 (5.5) | 0.198 |
| Previous suicidal attempt (%) | 5 (8.2) | 71 (12.9) | 0.518 |

[a] Diabetes mellitus, hypertension, hepatitis, cancer.
[b] Mental retardation, schizophrenia, anxiety, panic disorder.

**Table 3**
A comparison of the clinical characteristics of drowning patients between elderly group and adult group at emergency department.

| | Elderly (n = 61) | Adult (n = 550) | p |
|---|---|---|---|
| State on ED arrival (n, %) | | | 0.017 |
| Arrest | 17 (27.9) | 87 (15.9) | |
| Alive | 44 (72.1) | 463 (84.2) | |
| Mental status at ED arrival (n, %) | | | 0.015 |
| Alert | 30 (49.2) | 364 (66.2) | |
| Stupor | 1 (1.6) | 16 (2.9) | |
| Coma | 30 (49.2) | 170 (30.9) | |
| Initial body temperature (n, %) | | | 0.025 |
| <30 °C | 15 (24.6) | 63 (11.5) | |
| 30–31.9 °C | 0 | 12 (2.2) | |
| 32–33.9 °C | 2 (3.3) | 21 (3.8) | |
| 34–35.9 °C | 29 (47.5) | 244 (44.4) | |
| ≥36 °C | 8 (13.1) | 130 (23.6) | |
| Unknown | 6 (9.8) | 80 (14.5) | |
| Required invasive airway (n,%) | 16 (26.2) | 86 (15.6) | 0.035 |
| Result of ED treatment (n,%) | | | 0.01 |
| Discharge to home | 18 (29.5) | 263 (47.8) | |
| Transfer to other hospital | 4 (6.6) | 51 (9.3) | |
| Admit to general ward | 2 (3.3) | 33 (6.0) | |
| Admit to intensive care unit | 14 (23.0) | 83 (15.1) | |
| Death before admission | 23 (37.7) | 120 (21.8) | |

ED, emergency department.

and low temperatures. [25] And the lower subcutaneous fat in elderly may contribute the hypothermia. So, various vigorous efforts to raise body temperature in the elderly drowning patients will be needed.

In this study, suicide attempts were the most common cause of drowning in both the elderly and in adults. In South Korea, suicide is the leading cause of death in adult patients. Suicide is also one of the leading causes of death among elderly people aged over 60 years. Korea has had the highest elderly suicide rate among Organization for Economic Cooperation and Development countries for the last 10 years. Based on statistics by age group from 2015, the suicide rate tended to decrease in most age groups, but it increased in patients aged in their 70s (8.5%) and those aged over 80 years (6.4%). [26] KH Kim et al. reported that 35.1% of elderly suicide patients that visited the ED had major depressive disorder and 28.6% had a prior suicide attempt. [27] The prevalence of depression in people who attempt suicide is a major factor. [28,29] In this study, while only 9.8% of elderly patients were diagnosed with major depressive disorder and 8.2% had previously attempted suicide, 82% of elderly patient had attempted to drown intentionally, which is a high rate. In the elderly, depression is often difficult to diagnose due to non-specific symptoms and complicated etiologies. The result seems to be a large number of undiagnosed depression cases in hospitals. [30,31] Therefore, an elderly mental health care program should be implemented systematically at the government level.

SH. Woo et al. noted that intentional drowning patients commonly jumped from the riverside; therefore, equipment, such as message of hope, call of life or a walker detecting sensor, should be placed at the riverside to prevent suicides. [6] However, despite the effort of making the fences of bridges higher did not diminish the number of accidents. [32] In this study, there was a significant difference in rate between the suicide sites of elderly and adult drowning patients. Elderly patients had a higher rate of drowning at riverside compared with adult. These results indicate that to elderly, the riverside is more accessible and is less fear-inducing in suicide attempts than a bridge. Most efforts to prevent drowning are focused on bridges. The results of this study suggest that it is also important to establish preventive measures against drowning in riverside. Further, because a fence is not installed along the riverside, it is thought that drowning events could occur more often. Therefore, efforts, such as installing walking fences at the riverside, should be made to prevent drowning attempts in the area. Elderly drowning attempts occurred more between 12:00–18:00 (44.3%), endorsing efforts to install a 24-h monitoring system to immediately detect suicidal events drowning or increasing patrol in this afternoon time should be considered.

There are some limitations to this study. First, this study was conducted at a single institution adjacent to a river, so its conclusions may not reflect the characteristics of various drowning cases in other environments, such as a sea or valley or swimming pool. Second, this cohort study includes a number of drowning due to suicidal attempt. Therefore, with these limitations, it is difficult to generalize the results with the data in this paper. Third, since this study is a retrospective study using medical records, it had a large amount of missing data. Nevertheless, this work is the first to analyze the characteristics of elderly drowning patients, which will help in the prevention and treatment of elderly drowning.

## 5. Conclusion

The elderly drowning patients accounted for approximately 1/10 of all drowning patients and had more cardiac arrests, hypothermia and higher symptom severity than adult patients, requiring more intensive care. As only a small number of patients were diagnosed with depression and the majority ere suicidal, a senior mental health care program should be created and expanded.

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*Conflicts of interest*

None of the authors have any financial or other relationships that might pose any conflicts of interest.

*Author contributions*

Lee DH was responsible for the study execution, data management, data analysis data interpretation, and manuscript writing. Wee JH was responsible for the study design, study execution, supervising of data management, data interpretation and manuscript writing. Choi SP, Park JH, Oh JH were responsible for data analysis and study design, interpretation of results and manuscript writing. All the authors read and approved the final manuscript.

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## References

[1] WHO. Drowning fact sheet; 2018.
[2] Oxford Martin Programme on Global Development. https://ourworldindata.org/grapher/drowning-death-rates-by-age?country=KOR, Accessed date: 1 May 2018.
[3] Kim K, Kim JY, Shin SD, Koh SB, Lee KJ, Im JS, et al. The epidemiologic characteristics of drowning in Korea. Journal of the Korean Society of Emergency Medicine 2008; 19:527–34.
[4] KOSTAT. Statistics Korea. Available at: http://kostat.go.kr/portal/korea/kor_ki/1/1/index.action?bmode=read&cd=S004001&tt=cate, Accessed date: 22 September 2017.
[5] Seoul Metropolitan Government. http://safe.seoul.go.kr/, Accessed date: 10 August 2018.
[6] Woo SH, Park JH, Choi SP, Wee JH. Comparison of clinical characteristics of intentional vs accidental drowning patients. Am J Emerg Med 2015;33:1062–5.
[7] KOSTAT. Statistics Korea. Available at: http://kostat.go.kr/portal/korea/kor_nw/2/6/1/index.board, Accessed date: 26 September 2017.
[8] Shah MN. Introduction: special content focus: geriatric emergency medicine. Acad Emerg Med 2010;17:231.
[9] Huang JF, Wong RH, Chen CC, Mao IF, Huang CC, Chang WH, et al. Trajectory of depression symptoms and related factors in later life—a population based study. J Affect Disord 2011;133:499–508.
[10] Quan L, Cummings P. Characteristics of drowning by different age groups. Inj Prev 2003;9:163–8.

[11] Hoek TLV, Morrison LJ, Shuster M, Donnino M, Sinz E, Lavonas EJ, et al. Part 12: cardiac arrest in special situations 2010 American Heart Association Guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation 2010; 122 (S829-S61).
[12] WHO. Definition of an older or elderly person. http://www.who.int/healthinfo/survey/ageingdefnolder/en/.htm, Accessed date: 9 April 2018.
[13] KMA, Korea Meteorological Administration. http://www.weather.go.kr/weather/climate/average_30years.jsp?yy_st=2011&stn=108&norm=M&x=18&y=5&obs=0, Accessed date: 15 May 2018.
[14] van Beeck EF, Branche C, Szpilman D, Modell JH, Bierens JJ. A new definition of drowning: towards documentation and prevention of a global public health problem. Bull World Health Organ 2005;83:853–6.
[15] Orlowski JP, Abulleil MM, Phillips JM. The hemodynamic and cardiovascular effects of near-drowning in hypotonic, isotonic, or hypertonic solutions. Ann Emerg Med 1989;18:1044–9.
[16] Grmec S, Strnad M, Podgorsek D. Comparison of the characteristics and outcome among patients suffering from out-of-hospital primary cardiac arrest and drowning victims in cardiac arrest. Int J Emerg Med 2009;2:7–12.
[17] Szpilman D, Bierens JJLM, Handley AJ, Orlowski JP. Drowning. N Engl J Med 2012; 366:2102–10.
[18] Pelkonen M, Notkola IL, Lakka T, Tukiainen HO, Kivinen P, Nissinen A. Delaying decline in pulmonary function with physical activity: a 25-year follow-up. Am J Respir Crit Care Med 2003;168:494–9.
[19] McKeever TM, Scrivener S, Broadfield E, Jones Z, Britton J, Lewis SA. Prospective study of diet and decline in lung function in a general population. Am J Respir Crit Care Med 2002;165:1299–303.
[20] Goldspink DF. Ageing and activity: their effects on the functional reserve capacities of the heart and vascular smooth and skeletal muscles. Ergonomics 2005;48: 1334–51.
[21] Tanaka H, Seals DR. Endurance exercise performance in Masters athletes: age-associated changes and underlying physiological mechanisms. J Physiol 2008;586: 55–63.
[22] Kirkwood TB. A systematic look at an old problem. Nature 2008;451:644–7.
[23] Rockwood K, Mitnitski A. Frailty defined by deficit accumulation and geriatric medicine defined by frailty. Clin Geriatr Med 2011;27:17–26.
[24] Gomez CR, Boehmer ED, Kovacs EJ. The aging innate immune system. Curr Opin Immunol 2005;17:457–62.
[25] Fillit HM. Brocklehurst's textbook of geriatric medicine and gerontology8th Edition. ; 2017.
[26] KOSIS. Korean Statistical Information Service. Available at http://kosis.kr/statisticsList/statisticsList_03List.jsp?vwcd=MT_RTITLE&parmTabId=M_03_01_01#SubCont, Accessed date: 29 September 2017.
[27] Kyoung Hwan K, lt, sup, gt, lt, sup, et al. The characteristics of elderly patients with suicide attempts: a comparative study with non-elderly patients. , vol. 20AGMR; 2016; 209–20.
[28] Jeon HJ, Lee JY, Lee YM, Hong JP, Won SH, Cho SJ, et al. Lifetime prevalence and correlates of suicidal ideation, plan, and single and multiple attempts in a Korean nationwide study. J Nerv Ment Dis 2010;198:643–6.
[29] Oquendo MA, Kamali M, Ellis SP, Grunebaum MF, Malone KM, Brodsky BS, et al. Adequacy of antidepressant treatment after discharge and the occurrence of suicidal acts in major depression: a prospective study. Am J Psychiatry 2002;159:1746–51.
[30] Sonnenberg CM, Beekman AT, Deeg DJ, Tilburg V. Drug treatment in depressed elderly in the Dutch community. Int J Geriatr Psychiatry 2003;18:99–104.
[31] Birrer RB, Vemuri SP. Depression in later life: a diagnostic and therapeutic challenge. Am Fam Physician 2004;69:2375–82.
[32] Kim HJ, Park JC. Technical overview of suicide prevention structure on bridge. , vol. 10Korean Society of Civil Engineers; 2014; 1663–4.