Clinical Medicine & Research
Volume 20, Number 4: 204-210

clinmedres.org

Original Research

Disease Staging: Prevalence of Cardiorespiratory Complications in Type 2 Diabetes Mellitus

Maria Cristina Carrondo, PhD

Introduction: The incidence of cardiorespiratory complications in diabetic patients is a major concern for healthcare organizations and providers in Portugal. The objectives of this study were (1) to study the prevalence of cardiorespiratory complications during hospitalization in the diabetic population and (2) to identify their associated factors.

Methods: This is a cross-sectional study and included 7,347 diabetic patients admitted to all specialty services enrolled between January 1, 2018 and December 31, 2018 in 32 public hospitals in Portugal. Hospital discharge summary data and both Disease-Related Diagnosis Groups and Disease Staging were used. Descriptive statistical analysis was used where the distribution and rates of cardiorespiratory complications were calculated. Logistic regression using the risk adjustment model was used to calculate the associated risk factors for cardiorespiratory complications.

Results: The total rate of cardiorespiratory complications was 18.2% cardiorespiratory complications; in women it was 21.5% and in men 15.6%. The comorbidity of congestive heart failure (98.0%) was significantly higher ($P<0.001$) among patients undergoing medical treatment, and the comorbidities bacterial pneumonia and coronary artery disease without prior coronary revascularization were significantly higher (63.9%, 45.1%, and 33.4%, $P<0.001$).

Discussion: The use of different therapies to control glucose levels and the absence of antibiotic prophylaxis during medical treatment may account for these data.

Conclusions: Cardiorespiratory complications were higher in women than in men and in those who received medical treatment. Comorbidities such as congestive heart failure, such as bacterial pneumonia and coronary artery disease without prior coronary revascularization were identified as risk factors.

Keywords: Extended tourniquet time; Newman's recommendations; Complex hindfoot surgery; Orthopaedic surgery; Foot and ankle

Corresponding Author: Maria Cristina Carrondo, PhD, Polytechnic Institute of Coimbra, College of Health Technology of Coimbra, Department of Medical, Social, and Human Sciences, Rua 5 Outubro, Sao Martinho do Bispo 3045-043, Coimbra, Portugal, Tel: (+351) 239802430, Email: maria.lourenco@estesc.ipc.pt, ORCID: 0000-0002-8603-0889

Ethical Considerations: This study was approved by the Central Administration of the Health System. The need for written informed consent from all participants was waived because this was a retrospective study with anonymized patient data.

Disclosure: The author has not declared any financial or personal conflicts of interest related to this work.

Received: June 5, 2021
Revised: August 8, 2022
Accepted: September 28, 2022

doi:10.3121/cmr.2022.1699

Over the past decade, type 2 diabetes mellitus (T2DM) has become a growing worldwide epidemic.[1,2] In 2015, approximately 415 million adults (aged 20-79 years) had T2DM and it is estimated that number will be 629 million by 2045.[1] Globally, the prevalence of diabetes in adults aged 18 years and older increased from 9.5% in 1999-2002 to 12.0% in 2013-2016.. In 2016, a total of 7.8 million hospital discharges were recorded, with diabetes listed as any diagnosis among U.S. adults aged 18-years and older (339.0 per 1,000 adults with diabetes). These discharges include: 1.7 million for major cardiovascular disease (75.3 per 1,000 adults with diabetes), including 438,000 for ischemic heart disease (18.9 per 1,000 adults with diabetes) and 313,000 for stroke (13.6 per 1,000 adults with diabetes)[3]. In Portugal, hospital admission rates for 88-870 adults increased 82.7% between 2006 and 2015, with acute myocardial infarction being the leading cause of hospitalization.[4]

Studies[5-7] have reported that cardiorespiratory complications are more prevalent in people with diabetes, particularly in older men. Among the most frequent cardiorespiratory complications in T2DM are arrhythmias and sudden death, coronary heart disease, cardiomyopathy, cerebrovascular disease, and peripheral artery disease.[8] Ma et al[9] showed that 3.2% of cardiorespiratory complications (such as postoperative pneumonia) were associated with hospitalization, and 1.8% of these complications were caused by multiple surgeries. It is difficult to determine the actual incidence of cardio-respiratory complications in Portuguese public hospitals, as there are no published studies. But in 2015, about 29.5% of patients with diabetes were admitted to public hospitals for stroke, and 32.4% for acute myocardial infarction[10].

Several studies[11-13] have reported that risk factors such as severe hypoglycemic complications, advanced age, and the presence of comorbidities (dyslipidemia, hypertension, obesity, and renal failure) may increase the occurrence of cardiorespiratory complications in patients with diabetes during hospitalization. Another study[14] showed that duration of surgery, number of reoperations, type of hospitalization, and admission to the intensive care unit were risk factors for complications during hospitalization in patients with T2DM.

This study aimed to investigate the prevalence of cardiorespiratory complications per episode and identify their risk factors per patient.

Methods

This is a cross-sectional study and medical data from the National Hospital Morbidity Database provided by the Central Administration of the Health System were used. The study was conducted in 32 public hospitals in Portugal between January 1 and December 31, 2018. The medical data of 7,347 patients with T2DM were reviewed. Inclusion criteria were hospitalized patients over age 18 years with T2DM as the main diagnosis. Exclusion criteria included patients with type 1 diabetes mellitus, with a history of cardiorespiratory complications, and with chronic obstructive pulmonary disease. The Diagnosis Related Groups (DRG) were used to identify T2DM episodes (DX codes 250.00) as the principal diagnosis and (2) Disease Staging[4,15] version 5.26 was used to identify the severity of T2DM, its comorbidities and stages, and cardiorespiratory complications.

The parameters for cardiorespiratory complications were as follows: code 42741, ventricular fibrillation; code 42724, ventricular flutter; code 5121, iatrogenic pneumothorax; code 5184, acute lung edema NOS; and code 51881, acute respiratory failure. Cardiorespiratory complications started from the first day of admission until discharge from the hospital were collected. Cardiorespiratory complications were defined as the adverse outcome and dependent variable that assumed the values: 0 (without infection) and 1 (with infection). Independent variables were selected from variables previously reported[4,16] as follows:

(1) Length of hospitalization;

(2) The three stages of severity of main disease;[4,15]

Table 1. Demographic characteristics

	Population	Total N (%)	Age (years), n (%)				
			18-64	65-74	75-84	> 85	Mean ± SD
Sex	Men	3757 (51.1)	1284 (60.7)	1053 (57.5)	1066 (45.8)	354 (33.0)	69±13
	Women	3590 (48.9)	832 (39.3)	779 (42.5)	1259 (54.2)	720 (67.0)	73±13
Severity of T2DM	Stage 1	428 (5.8)					
	Stage 2	2840 (38.7)					
	Stage 3	4079 (55.5)					
Treatment type	Surgical	1813 (24.7)					
	Medical	5534 (75.3)					

Abbreviations: T2DM, type 2 of diabetes mellitus; SD, standard deviation

(3) The comorbidities and stage: lipid abnormalities (NUT82); essential hypertension (CVS13); obesity (NUT02); coronary artery disease without prior coronary revascularization (CVS11); cerebrovascular disease (NEU04); congestive heart failure (CVS09); pneumonia: bacterial (RES15); renal failure (GUS08); other disorders of the respiratory system (RES83); rhino, adeno, and corona virus infections (RES24); neoplasm, malignant: colon and rectum (GIS27); neoplasm, malignant: lungs, bronchi, or mediastinum (RES13); and neoplasm, malignant: stomach (GIS30). For all comorbidities, I considered the three stages;[4,15]

(4) Treatment type: surgical and medical treatment (according to the DRG criteria).

(5) Age and sex.

Bivariate analysis was used to determine the prevalence of cardiorespiratory complications. The distribution and the rate of cardiorespiratory complications were calculated using the following formula:[17]

> Cardiorespiratory complication rate = total number of patients with complication/sum of patients at risk without complication and at risk with complication * 100.

Cardiorespiratory risk[4,15] was explicitly assessed according to the relationship between the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) principal and secondary diagnosis codes and defined as (i) a patient at risk for a specific complication and (ii) a patient with evidence of a potential complication during hospitalization.

Multivariate logistic regression analysis was used to determine the risk factors for cardiorespiratory complications (cardiorespiratory complications [dependent variable] and risk factors [independent variables]). The forward conditional method was used for stepwise selection of the variables, whereas the Hosmer and Lemeshow (H-L) test was used to adjust the model with the independent variables. For the validation of the model, its discriminatory capability, sensitivity, and specificity were analysed using the area under the curve of the receiver operating characteristic curve (AUROC) (c) OR values were presented with their respective 95% confidence intervals (CI) or *P* values. The *P* value set to indicate statistical significance was $P<0.05$. All statistical analyses were performed using the IBM SPSS Statistics for Windows, Version 23.0 (Armonk, NY: IBM Corp).

Table 2. Cardiorespiratory complications rate by sex, age, severity of T2DM, comorbidities, and treatment type

Variables		Rate (%)	OR	*P* value
Sex	Men (ref.)	15.6	1.48	<0.001
	Women	21.5		
Age (years)	18-64 (ref.)	9.7		
	65-74	15.6	1.71	<0.001
	75-84	25.2	3.12	<0.001
	Above 85	30.2	4.03	<0.001
Severity of T2DM	Stage 1 (ref.)	13		
	Stage 2	6.7	0.48	0.019
	Stage 3	28.3	2.65	<0.001
Comorbidities	NUT82 (ref.)	18.5		
	CVS13	32.9	2.16	<0.001
	NUT02	27.2	1.65	<0.001
	CVS11	33.4	2.21	<0.001
	NEU04	23.5	1.35	0.035
	CVS09	98	211.68	<0.001
	RES15	45.1	3.62	<0.001
	GUS08	34.2	2.29	<0.001
	RES83	63.9	7.79	<0.001
	RES24	45.1	3.62	<0.001
	GIS27	19	1.04	0.898
	RES13	0	0.16	0.191
	GIS30	38.9	2.81	0.035
Treatment type	Surgical (ref.)	9.7	3.19	<0.001
	Medical	25.4		

NUT82, lipid abnormalities; CVS13, essential hypertension; NUT02, obesity; CVS11, coronary artery disease without prior coronary revascularization; NEU04, cerebrovascular disease; CVS09, congestive heart failure; RES15, pneumonia: bacterial; GUS08, renal failure; RES83, other disorders of the respiratory system; RES24, rhino, adeno, and corona virus infections; GIS27, neoplasm, malignant: colon and rectum; RES13, neoplasm, malignant: lungs, bronchi, or mediastinum; GIS30, neoplasm, malignant: stomach. Rate (%) = Total number of patients with complication/ sum of patient at risk without complication and at risk with complication *100, Abbreviation: T2DM, type 2 of diabetes mellitus; OR, odds ratio; ref., reference group.

Results

Study Participants

Of the 7,347 patients with T2DM who were admitted, 3,757 (51.1%) patients were men, and 3,590 (48.9%) were women. Most patients were elderly: 71.1% of the participants were over 61 years-of-age. The average length of hospital stay was 12 days (SD ± 18 days). The total rate of cardiorespiratory complications was 18.2%. Patient characteristics are shown in Table 1.

Cardiorespiratory Complication Rates

Rates of cardiorespiratory complications were higher in women than in men (21.5% vs 15.6%; OR=1.48; $P<0.001$), and significantly higher in those who received medical treatment than in those who received surgical treatment

Table 3. Logistic regression analysis for cardiorespiratory complications in diabetic patient.

Cardiorespiratory complications		
Independent variables	**OR**	**(95% CI)**
Age (years)	1.029	(1.017-1.040)
Duration of hospitalization (days)	1.009	(1.004-1.014)
Stages NEU04		
Without (Ref.)	1	
Stage 1	1.798	(1.121-2.883)
Stages RES15		
Without (Ref.)	1	
Stage 1	2.067	(1.319-3.238)
Stage 2	3.811	(1.378-10.537)
Stage 3	94.370	(20.115-442.729)
Stages RES24		
Without (Ref.)	1	
Stage 1	3.824	(2.005-7.295)
Stages CVS11		
Without (Ref.)	1	
Stage 1	1.694	(1.183-2.425)
Stage 2	38.562	(22.009-67.562)
Stage 3	8.245	(3.878-17.530)
Stages GUS08		
Without (Ref.)	1	
Stage 3	3.868	(1.298-11.524)
Stages CVS13		
Without (Ref.)	1	
Stage 3	2.787	(2.082-3.731)
Stages RES83		
Without (Ref.)	1	
Stage 1	2.128	(1.004-4.509)
Stage 2	11.693	(7.176-19.054)
Stage 3	836.791	(56.740-12340.760)
Stages CVS09		
Without (Ref.)	1	
Stage 3	642.300	(221.745-1860.471)
Stages NUT02		
Without (Ref.)	1	
Stage 2	1.614	(1.531-241.126)
Constant	1621.210	

NEU04, cerebrovascular disease; RES15, bacterial pneumonia; RES24, rhino, adeno, and corona virus infections; CVS11, coronary artery disease without prior coronary revascularization; GUS08, renal failure; CVS13, essential hypertension; RES83, other disorders of the respiratory system; CVS09, congestive heart failure; NUT02, obesity
Abbreviations: OR, odds ratio; CI, confidence interval; Ref., reference group; T2DM, type 2 of diabetes mellitus

(25.4% vs 9.7%; OR=3.19; P<0.001). Table 2 shows the cardiorespiratory complication rate values by sex, age (stratified), T2DM severity, comorbidities, and type of treatment.

Risk Factors

Multivariate regression analysis showed the predictors of cardiorespiratory complications were as follows: age 18 years and older (OR=1.029; 95% CI=1.017-1.040); duration of hospitalization (OR=1.009; 95% CI=1.004-1.014); comorbidity of cerebrovascular disease stage 1 (OR=1.798; 95% CI=1.121-2.883); comorbidity of bacterial pneumonia stage 1 (OR=2.067; 95% CI=1.319-3.238), stage 2 (OR=3.811; 95% CI=1.378-10.537), and stage 3 (OR=94.370; 95% CI=20.115-444.729); comorbidity of stage 1 rhinovirus, adeno, and coronavirus infections (OR=3.824; 95% CI=2.005-7.295); comorbidity of stage 1 coronary artery disease without prior coronary revascularization (OR=1.694; 95% CI=1.183-2.425), stage 2 (OR=38.562; 95% CI=22.009-67.562) and stage 3 (OR=8.245; 95% CI=3.878-17.530); comorbidity of stage 1 renal failure (OR=3.868; 95% CI=1.298-11.524); comorbidity of stage 1 essential hypertension (OR=2.787; 95% CI=2.082-3.731); stage 1 comorbidity of other respiratory system disorders (OR=2.128; 95% CI=1.004-4.509), stage 2 (OR=11.693; 95% CI=7.176-19.054), and stage 3 (OR=836.791; 95% CI=56.740-12340.760); stage 3 congestive heart failure comorbidity (OR=642.300; 95% CI=221.745-1860.471); and stage 2 obesity comorbidity (OR=1.614; 95% CI=1.531-241.126. Table 3 shows the result of the logistic regression analysis with cardiorespiratory complications as the dependent variable. The P value found for the model was P <0.001 in Table 4. The H-L test revealed a P value of 0.970 in Table 5, and the area under curve was 0.926, indicating the model had a good sensitivity and specificity.

Discussion

In this study, individuals with diabetes who were at higher risk for cardiorespiratory complications during hospitalization were identified. The rate of cardiorespiratory complications in our study was 18.2% and was more frequent in elderly women than in men, contradicting previous studies,[6,7,18] which indicate a higher and more frequent rate in men. A possible explanation for these results could be different study designs and differences in delivery systems and health care for the diabetic population.

With regard to diabetes severity, this study found a higher rate of cardiorespiratory complications in stage 1 diabetics than in those with stage 2 diabetes (13.0% vs 6.7% respectively; OR=0.48), also contradicting previous studies.[19,2] However, Stahn et al[21] showed that diabetics using metformin and/or dipeptidyl peptidase-4 inhibitors to control their disease had more asymptomatic and severe hypoglycaemia and more ventricular arrhythmias than patients taking insulin and/or sulfonylurea, in addition to knowing their cardiovascular disease, so our results may indicate ineffective glycemic

Table 4. Omnibus tests of model coefficients

		Chi-square	Df	Sig.
Step 1	Step	662.145	1	.000
	Block	662.145	1	.000
	Model	662.145	1	.000
Step 2	Step	281.015	3	.000
	Block	943.160	4	.000
	Model	943.160	4	.000
Step 3	Step	247.381	3	.000
	Block	1190.541	7	.000
	Model	1190.541	7	.000
Step 4	Step	123.207	3	.000
	Block	1313.748	10	.000
	Model	1313.748	10	.000
Step 5	Step	144.300	2	.000
	Block	1458.047	12	.000
	Model	1458.047	12	.000
Step 6	Step	53.268	3	.000
	Block	1511.315	15	<0.001
	Model	1511.315	15	<0.001
Step 7	Step	41.217	2	.000
	Block	1552.532	17	<0.001
	Model	1552.532	17	<0.001
Step 8	Step	55.486	3	.000
	Block	1608.018	20	<0.001
	Model	1608.018	20	<0.001
Step 9	Step	136.110	50	.000
	Block	1744.128	70	<0.001
	Model	1744.128	70	<0.001
Step 10	Step	30.199	1	.000
	Block	1774.327	71	<0.001
	Model	1774.327	71	<0.001
Step 11	Step	10.602	1	<0.001
	Block	1784.929	72	<0.001
	Model	1784.929	72	<0.001
Step 12	Step	11.166	3	.011
	Block	1796.094	75	<0.001
	Model	1796.094	75	<0.001
Step 13	Step	8.332	1	.004
	Block	1804.426	76	<0.001
	Model	1804.426	76	<0.001
Step 14	Step	5.484	2	.064
	Block	1809.910	78	<0.001
	Model	1809.910	78	<0.001

Abbreviations: Df, degrees of freedom; Sig., significance

Table 5. Hosmer and Lemeshow test

Step	Chi-square	Df	Sig.
1	.000	0	.
2	.000	1	1
3	0.380	1	0.537
4	2.122	2	0.346
5	5.361	3	0.147
6	11.469	5	0.043
7	13.726	5	0.017
8	22.169	7	0.002
9	12.637	8	0.125
10	10.376	8	0.240
11	10.917	8	0.206
12	10.063	8	0.080
13	10.792	8	0.045
14	10.475	8	0.097

Abbreviations: Df, degrees of freedom; Sig., significance

control in patients with stage 1 diabetes and differences in the medication used for diabetes control

This study indicates the cardiorespiratory complication was more frequent after medical treatment than after surgical treatment, contradicting previous studies.[22] This is attributed to the antihyperglycemic therapies administered to diabetics with poor glycemic control during hospitalization.[22,23] The difference in the frequency of cardiorespiratory complications between treatment types may be due to the different therapeutic strategies used to control glucose levels, so I speculated that (i) antibiotic prophylaxis was administered in patients undergoing surgery, and (ii) there was better management of these patients throughout the perioperative period. In addition, most of these diabetics are not treated by endocrinology or internal medicine during hospitalization, which may also contribute to these results.

Several epidemiological studies[19,22-25] have shown that the duration and type of cardiorespiratory complications increase the likelihood that a patient with T2DM will have worsening comorbidities. The present study found that cerebrovascular disease, bacterial pneumonia, rhino, adeno, and coronavirus infections, coronary artery disease without prior coronary revascularization, renal failure, hypertension, congestive heart failure, obesity, and other respiratory system disorders were risk factors for cardiorespiratory complications. These results may be justified by metabolic disturbances such as insulin resistance, compensatory hyperinsulinemia, inflammation,[26] and hypoglycemia.[27,28] These results indicate the need for more effective clinical safety protocols for physicians and nursing staff. However, the comorbidity of

bacterial pneumonia and the comorbidity of other respiratory system disorders may be due to (1) ineffective prophylactic measures, (2) differences in clinical practice, and (3) differences in hospital resource utilization, such as previous studies.[4,27,28]

This study has some limitations. First, it lacks biochemical data, particularly glycemic values at pre- and post-treatment that may result in less favorable outcomes. And second, it is not know whether the cause of the cardiorespiratory complication was preventable or not, because ICD9 codes were used. In future studies, other instruments such as clinical files and biochemical data results should be used. However, ICD9 or ICD10 codes should continue to be used, because they are easily accessible, allowing us to use them in large samples, as is the case in the present study.

Conclusion

The study concluded that the highest risk factors associated with cardiorespiratory complications were congestive heart failure, bacterial pneumonia, and coronary artery disease without prior coronary revascularization, and the rate of complications was more frequent in women undergoing medical treatment. Given the increasing incidence of T2DM in Portugal, effective guidelines on diabetes management before and after hospitalization are needed. In the inpatient setting, more effective health policies should be implemented to manage T2DM, namely involving internal medicine and endocrinology services, as diabetics may be hospitalized in different specialty services. Blood glucose should be monitored before and after medical treatments, and safe protocols should be adopted to reduce cardiorespiratory complications. In the outpatient setting, home visits by nurses are crucial for those with limited access to health care to help diabetic patients manage their disease and risk factors, such as hypertension and obesity. Another health policy should be health education on diet and nutrition to be adopted by patients to reduce metabolic risk factors and to make them aware of the silent signs and symptoms of their disease to prevent late complications. More national studies should be conducted, and the results disseminated to ensure better clinical practice.

Acknowledgements

The author would like to thank Dr. Carlos Costa.

References

1. International Diabetes Foundation. Diabetes Atlas IDF. 9th ed. 2019. Available at: https://diabetesatlas.org/atlas/ninth-edition/.
2. Zheng Y, Ley SH, Hu FB. Global aetiology and epidemiology of type 2 diabetes mellitus and its complications. Nat Rev Endocrinol. 2018;14(2):88-98. doi:10.1038/nrendo.2017.151.
3. Centers for Disease Control and Prevention. Diabetes. National Diabetes Statistics Report, 2020. Available at: https://www.cdc.gov/diabetes/data/statistics-report/index.html.
4. Carrondo MC. Diabetic women: Inpatient mortality risk before SARS-CoV-2. Obesity Medicine. 2022;32:100413. doi:10.1016/j.obmed.2022.100413.
5. Lara-Rojas CM, Pérez-Belmonte LM, López-Carmona MD, et al. National trends in diabetes mellitus hospitalization in Spain 1997–2010: Analysis of over 5.4 millions of admissions. Eur J Intern Med. 2019;60:83-89. doi:10.1016/j.ejim.2018.04.005.
6. Akoum N, Zelnick LR, de Boer IH, et al. Rates of Cardiac Rhythm Abnormalities in Patients with CKD and Diabetes. Clin J Am Soc Nephrol. 2019;14(4):549-556. doi:10.2215/CJN.09420818.
7. Yang R, Pedersen NL, Bao C, et al. Type 2 diabetes in midlife and risk of cerebrovascular disease in late life: a prospective nested case−control study in a nationwide Swedish twin cohort. Diabetologia. 2019;62(8):1403-1411. doi:10.1007/s00125-019-4892-3.
8. Viigimaa M, Sachinidis A, Toumpourleka M, et al. Macrovascular Complications of Type 2 Diabetes Mellitus. Curr Vasc Pharmacol. 2020;18(2):110-116. doi :10.2174/1570161117666190405165151.
9. Ma CM, Liu Q, Li M, et al. The Effects of Type 2 Diabetes and Postoperative Pneumonia on the Mortality in Inpatients with Surgery. Diabetes Metab Syndr Obes. 2019;12:2507-2513. doi:10.2147/DMSO.S232039.
10. Raposo JF. Diabetes na Doença Coronária: O Risco do Não Diagnóstico [Diabetes in Coronary Disease: The Risk of Non-Diagnosis]. Acta Med Port 2017; 30(6): 429 – 430. Portuguese.
11. Amiel SA, Aschner P, Childs B, et al; International Hypoglycaemia Study Group. Hypoglycaemia, cardiovascular disease, and mortality in diabetes: epidemiology, pathogenesis, and management. Lancet Diabetes Endocrinol. 2019;7(5):385-396. doi:10.1016/S2213-8587(18)30315-2.
12. Glovaci D, Fan W, Wong ND. Epidemiology of Diabetes Mellitus and Cardiovascular Disease. Curr Cardiol Rep. 2019;21(4):21. doi:10.1007/s11886-019-1107-y.
13. Mendez-Bailon M, Lorenzo-Villalba N, Muñoz-Rivas N, et al. Transcatheter aortic valve implantation and surgical aortic valve replacement among hospitalized patients with and without type 2 diabetes mellitus in Spain (2014–2015). Cardiovasc Diabetol. 2017;16(1):144. doi:10.1186/s12933-017-0631-6.
14. Haque M, Sartelli M, McKimm J, Abu Bakar MB. Health care-associated infections – an overview. Infect Drug Resist. 2018;11:2321-2333. doi:10.2147/IDR.S177247.

15. Thomson Reuteurs. Disease Staging: Clinical and Coded Criteria, Version 5.27. Ann Arbor, Michigan: The MEDSTAT Group, Inc.; 2009. Available at: https://www.hcup-us.ahrq.gov/db/nation/nis/DiseaseStagingV5_27ClinicalandCodedCriteria.pdf. Accessed January 6, 2020.
16. Iezzoni LI. Reasons for risk adjustment. In: Iezzoni LI, ed. Risk adjustment for measuring health care outcomes. 3rd ed. Chicago: Health Administration Press, American College of Healthcare Executives; 2003.
17. Fletcher RH, Fletcher SW. Fletcher's Clinical Epidemiology. 4th ed. North Carolina: Lippincott Williams & Wilkins; 2006.
18. Ávila AC, Fenili R. Incidence and risk factors for postoperative pulmonary complications in patients undergoing thoracic and abdominal surgeries. Rev Col Bras Cir. 2017;44(3):284-292. doi:10.1590/0100-69912017003011.
19. Wang Y, Yang H, Huynh Q, et al. Diagnosis of Nonischemic Stage B Heart Failure in Type 2 Diabetes Mellitus. JACC Cardiovasc Imaging. 2018;11(10):1390-1400. doi:10.1016/j.jcmg.2018.03.015.
20. Umpierrez GE, Smiley D, Jacobs S, et al. Randomized study of basal-bolus insulin therapy in the inpatient management of patients with type 2 diabetes undergoing general surgery (RABBIT 2 surgery). Diabetes Care. 2011;34(2):256-261. doi:10.2337/dc10-1407.
21. Stahn A, Pistrosch F, Ganz X, et al. Relationship between hypoglycemic episodes and ventricular arrhythmias in patients with type 2 diabetes and cardiovascular diseases: silent hypoglycemias and silent arrhythmias. Diabetes Care. 2014;37(2):516-520. doi:10.2337/dc13-0600.
22. Grisanti LA. Diabetes and Arrhythmias: Pathophysiology, Mechanisms and Therapeutic Outcomes. Front Physiol. 2018;9:1669. doi:10.3389/fphys.2018.01669.
23. Ferrini M, Johansson I, Aboyans V. Heart failure and its complications in patients with diabetes: Mounting evidence for a growing burden. Eur J Prev Cardiol. 2019;26(2_suppl):106-113. doi:10.1177/2047487319885461.
24. Erener S. Diabetes, infection risk and COVID-19. Mol Metab. 2020;39:101044. doi:10.1016/j.molmet.2020.101044.
25. Nichols GA, Hillier TA, Erbey JR, Brown JB. Congestive heart failure in type 2 diabetes: prevalence, incidence, and risk factors. Diabetes Care. 2001;24(9):1614-1619. doi:10.2337/diacare.24.9.1614.
26. Braunwald E. Diabetes, heart failure, and renal dysfunction: The vicious circles. Prog Cardiovasc Dis. 2019;62(4):298-302. doi:10.1016/j.pcad.2019.07.003.
27. de Decker L, Hanon O, Boureau AS, et al. Association between hypoglycemia and the burden of comorbidities in hospitalized vulnerable older diabetic patients: A cross-sectional, population-based study. Diabetes Ther. 2017;8(6):1405-1413. doi:10.1007/s13300-017-0319-7.
28. Valent F, Tonutti L, Grimaldi F. Does diabetes mellitus comorbidity affect in-hospital mortality and length of stay? Analysis of administrative data in an Italian Academic Hospital. Acta Diabetol. 2017;54(12):1081-1090. doi:10.1007/s00592-017-1050-6.

Author Affiliation

*Maria Cristina Carrondo, PhD**

**Department of Clinical Physiology, Polytechnic Institute of Coimbra, College of Health Technology of Coimbra, Department of Medical, Social, and Human Sciences, Coimbra, Portugal*