

Supplementary Materials

Table S1. (a). The performance of feature selection method_Information Gain (IG) depending on the weights and classifiers.

Information Gain Weight (Gene Number)	Classification Algorithms, Accuracy (%)		
	Naïve Bayes	K-NN (K = 3)	SVM
≥0.015 (17)	79.54	72.32	78.34
≥0.011 (78)	92.31	68.98	80.98
≥0.008 (95)	92.55	68.48	81.21
≥0.005 (537)	99.04	66.31	83.86

The highest values are bolded. K-NN, K-Nearest Neighbor; K, number of nearest neighbors; SVM, Support Vector Machine.

Table S1. (b). The performance of feature selection method_Chi-squared depending on the sample sizes and classifiers.

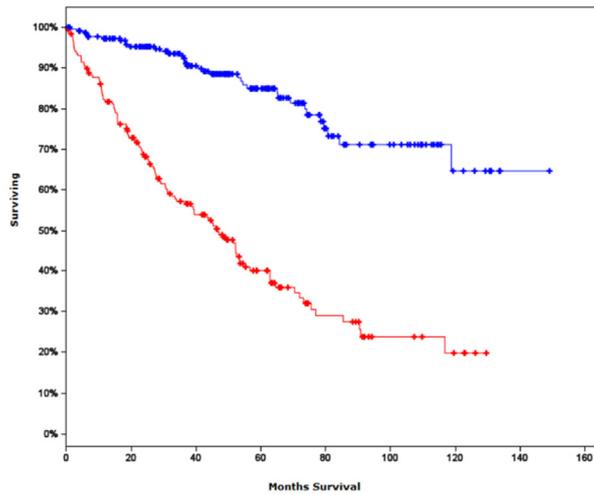
Chi-squared Sample size (Gene Number)	Classification Algorithms, Accuracy (%)		
	Naïve Bayes	K-NN (K = 3)	SVM
≥7 (20)	79.54	72.56	77.63
≥5 (85)	91.59	68.48	80.73
≥3 (461)	86.6	66.07	81.21
≥2 (621)	97.37	66.07	83.61

The highest values are bolded. K-NN, K-Nearest Neighbor; K, number of nearest neighbors; SVM, Support Vector Machine.

Table S1. (c). The performance of feature selection method_MRMR depending on the numbers of relevant genes and classifiers.

MRMR Number of Relevant Genes	Classification Algorithms, Accuracy (%)		
	Naïve Bayes	K-NN (K = 3)	SVM
Top 10	42.55	68.25	68.76
Top 20	76.67	72.58	72.84
Top 30	80.75	72.56	77.86
Top 100	93.49	67.27	83.39

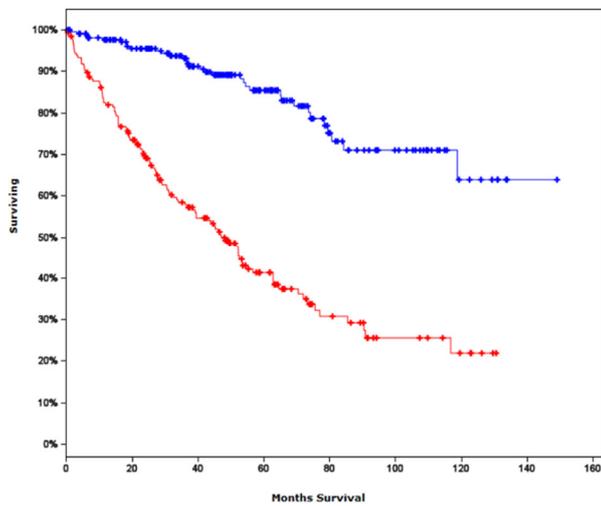
The highest values are bolded. MRMR, Minimum Redundancy-Maximum Relevance; K-NN, K-Nearest Neighbor; K, number of nearest neighbors; SVM, Support Vector Machine.



▷ **Information Gain (Survival-related Top 100 genes)**

- *p* - value: <0.001

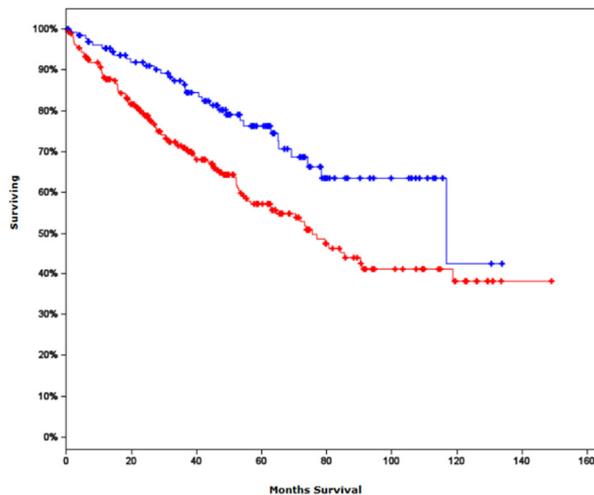
	Total	Decease	Median Survival (Months)	Decease (%)
Mutation Positive	190	112	46.55	58.9
Mutation Negative	227	35	NA	15.4
	37	77		43.5



▷ **Chi-square (Survival-related Top 100 genes)**

- *p* - value: <0.001

	Total	Decease	Median Survival (Months)	Decease (%)
Mutation Positive	198	114	47.04	57.6
Mutation Negative	219	33	NA	15.1
	21	88		42.5



▷ **MRMR (Survival-related Top 100 genes)**

- *p* - value: <0.00112

	Total	Decease	Median Survival (Months)	Decease (%)
Mutation Positive	286	115	75.53	40.2
Mutation Negative	131	32	116.75	24.4
	155	83	41.22	15.8

Figure S1. Survival curves of top 100 genes by three feature selection methods (Information Gain, Chi-squared test, and MRMR). NA, not available; MRMR, Minimum Redundancy-Maximum Relevance.

Table S2. A total of 123 survival-specific mutations selected in TCGA-KIRC using three feature selection methods (Information Gain, Chi-squared test, and MRMR).

Feature Variable (Clinicopathologic Factors)	Clinicopathologic Factor-Related Mutant Gene Number	Survival-Specific Mutant Gene Number
Age	109	15
Gender	68	9
Stage	76	32
Recurrence	40	38
Metastasis	58	30
Survival	42	34
Total (deduplicated)	195	123

Table S3. A total of 21 of top-ranked mutant genes above 5% in TCGA-KIRC.

Gene	Mutation Frequency (%)	Mutation Number	Sample Number
<i>VHL</i>	49.9	241	225
<i>PBRM1</i>	30.6	141	138
<i>MUC4</i>	17.1	129	77
<i>TTN</i>	15.5	84	70
<i>MUC16</i>	12.9	83	58
<i>SETD2</i>	11.3	58	51
<i>BAP1</i>	8.9	42	40
<i>MTOR</i>	7.1	33	32
<i>FBN2</i>	6.7	39	30
<i>XIRP2</i>	6.2	30	28
<i>KDM5C</i>	6	27	27
<i>DNAH3</i>	6	33	27
<i>HMCN1</i>	5.8	26	26
<i>ARID1A</i>	5.5	28	25
<i>TSHZ3</i>	5.5	32	25
<i>ARAP3</i>	5.5	38	25
<i>SSH2</i>	5.3	28	24
<i>VWF</i>	5.1	35	23
<i>AKAP9</i>	5.1	29	23
<i>SPEN</i>	5.1	25	23
<i>NAV3</i>	5.1	26	23

Table S4. A total of 14 genes for other solid tumors.

Gene	Mutation Frequency (%)	Mutation Number	Sample Number
<i>BRAF</i>	0.4	3	2
<i>BRCA1</i>	1.1	6	5
<i>BRCA2</i>	1.6	7	7
<i>EGFR</i>	2	9	9
<i>ALK</i>	0.9	4	4
<i>ERBB2 (HER2)</i>	0.9	4	4
<i>IDH1</i>	0.4	2	2
<i>IDH2</i>	1.1	5	5
<i>MYCN</i>	0.2	1	1
<i>MYC</i>	NA	NA	NA
<i>KIT</i>	NA	NA	NA
<i>KRAS</i>	0.2	1	1
<i>PDGFRA</i>	1.1	6	5
<i>NRAS</i>	NA	NA	NA

NA, not available.

Table S5. The Pearson's correlation test revealed that the presence of a mutation in *CARD6* was inversely related to the period of OS (Patient P10: 14 months, the shortest).

Characteristics		<i>CARD6</i> Mutation			
Overall Survival, Month	Patient <i>n</i> (%)	Yes	No	<i>r</i>	<i>p</i> -Value
				-0.441	0.04
10–20	3 (14%)	1	2		
21–30	1 (4%)	0	1		
31–40	12 (54%)	0	12		
41–50	6 (27%)	0	6		

Table S6. The Pearson's correlation test showed that the presence of the *BAP1* mutation was moderately negatively related to the period of DFS (Patient P8: 28 months and alive, Patient P12: 0 month and alive, Patient P16: 1 month and dead, and Patient P22:1 month and dead).

Characteristics		<i>BAP1</i> Mutation			
Disease Free Survival, Month	Patient <i>n</i> (%)	Yes	No	<i>r</i>	<i>p</i> -Value
				-0.465	0.029
0–9	5 (23%)	3	2		
10–20	4 (18%)	0	4		
21–30	3 (14%)	1	2		
31–40	8 (36%)	0	8		
41–50	2 (9%)	0	2		

Table S7. The Pearson's correlation test revealed that the presence of a mutation in *SECISBP2L* was rigorously related to the spread of cancer cells to the lymph nodes and positively related to death (Patient P11: positive and dead).

Characteristics		SECISBP2L Mutation			
	Patient <i>n</i> (%)	Yes	No	<i>r</i>	<i>p</i> -Value
N-stage (Lymph Nodes)				1	2.20e-16
Positive (1)	1 (5%)	1	0		
Negative (0)	21 (95%)	0	21		
Death				0.463	0.03
Dead (1)	4 (18%)	1	3		
Alive (0)	18 (82%)	0	18		

Table S8. The Pearson's correlation test revealed that the presence of a mutation in *SETD2* was moderately related to nuclear grade (Patient P3: grade 4, Patient P5: grade 3, Patient P8: grade 3, Patient P11: grade 4, Patient P12: grade 4, Patient P18: grade 2, Patient P20: grade 3, Patient P21: grade 3 and Patient P22: grade 4).

Characteristics		SETD2 Mutation			
	Patient <i>n</i> (%)	Yes	No	<i>r</i>	<i>p</i> -Value
Nuclear Grade				0.451	0.035
1	0	0	0		
2	6 (27%)	1	5		
3	11 (50%)	4	7		
4	5 (23%)	4	1		

Table S9. The Pearson's correlation test revealed that the presence of a mutation in *NLRP2* was strongly associated with sarcomatoid component (Patient P5: positive).

Characteristics		NLRP2 Mutation			
	Patient <i>n</i> (%)	Yes	No	<i>r</i>	<i>p</i> -Value
Sarcomatoid Component				0.69	0.0004
Positive (1)	2 (10%)	1	1		
Negative (0)	20 (90%)	0	20		

Table S10. Although mutation in *OBSCN* and sex were moderately associated, we noticed that both patients had *OBSCN* mutation were female (Patient P6 and Patient P12) in this case. It is also observed that Patient P12 had sarcomatoid component (Patient P12: positive).

Characteristics		OBSCN Mutation			
	Patient <i>n</i> (%)	Yes	No	<i>r</i>	<i>p</i> -Value
Sex				0.462	0.03
Male (0)	15 (68%)	0	15		
Female (1)	7 (32%)	2	5		
Sarcomatoid Component				0.474	0.026
Positive (1)	2 (10%)	1	1		
Negative (0)	20 (90%)	1	19		

Table S11. The Pearson's correlation test revealed that the presence of a mutation in *USP40* was strongly associated with having sarcomatoid component (Patient P5: positive).

Characteristics		USP40 Mutation			
	Patient <i>n</i> (%)	Yes	No	<i>r</i>	<i>p</i> -Value
Sarcomatoid Component				0.69	0.00038
Positive (1)	2 (10%)	1	1		
Negative (0)	20 (90%)	0	20		

Table S12. The Pearson's correlation test revealed that the presence of a mutation in *AKAP9* was strongly associated with having sarcomatoid component (Patient P5: positive).

Characteristics		AKAP9 Mutation		<i>r</i>	<i>p</i> -Value
	Patient <i>n</i> (%)	Yes	No		
Sarcomatoid Component				0.69	0.00038
Positive (1)	2 (10%)	1	1		
Negative (0)	20 (90%)	0	20		

Table S13. The Pearson's correlation test revealed that the presence of a mutation in *KDM5C* was strongly related to the fact that cancer tissue had spread to the nearby lymph nodes (P11: positive).

Characteristics		KDM5C Mutation		<i>r</i>	<i>p</i> -Value
	Patient <i>n</i> (%)	Yes	No		
N-stage (Lymph Nodes)				0.69	0.00038
Positive (1)	1 (5%)	1	0		
Negative (0)	21 (95%)	1	20		

Table S14. The Pearson's correlation test revealed that *ADAMTS10* mutation was moderately associated with tumor size. Patient P18 had *ADAMTS10* mutation showed the largest tumor size (14.5cm) among 22 patients (size of tumors without mutation- mean: 6.2 cm, median: 5.5 cm).

Characteristics		ADAMTS10 Mutation		<i>r</i>	<i>p</i> -Value
	Patient <i>n</i> (%)	Yes	No		
Tumor Size, cm				0.585	0.004
≤7.0	14 (63%)	0	16		
>7.0	8 (37%)	1	5		

Table S15. The Pearson's correlation test revealed that *ARID1A* mutation is moderately associated with tumor size. Patient P18 had *ARID1A* mutation showed the largest tumor size (14.5 cm) among 22 patients.

Characteristics		ARID1A Mutation		<i>r</i>	<i>p</i> -Value
	Patient <i>n</i> (%)	Yes	No		
Tumor Size, cm				0.585	0.004
≤7.0	14 (63%)	0	16		
>7.0	8 (37%)	1	5		