Journal of Stem Cell Research and Transplantation

Open Access

Austin Publishing Group

Review Article

Primary Cholangiocellular Carcinoma Cell Lines

Sebastian Zach*#, Emrullah Birgin# and Felix Rückert
Department of Surgery, Medical Faculty Mannheim, University of Heidelberg, Germany
#Equally contributed

***Corresponding author:** Sebastian Zach, Department of Surgery Medical Faculty Mannheim, University of Heidelberg, Theodor-Kutzer-Ufer 1-368167; Mannheim, E-mail: sebastian.zach@umm.de

Received: December 03, 2014; **Accepted:** January 18, 2015; **Published:** January 20, 2015

Abstract

Cholangiocellular Cancer (CCC) is a deadly disease and 5-year overall survival still is below 10%. To improve prognosis of patients with CCC, basic science is absolutely dependent on cell lines to elaborate new insights into pathological, diagnostic and therapeutic options. This is a systematic review about CCC cell lines described in literature to date. Different cell lines were established and characterized in the last 30 years. CCC cell lines can generally be classified into cell lines derived from intrahepatic CCC (iCCC), extrahepatic CCC (eCCC), perihilar CCC (Klatskin) and metastasis. The aim of this review is to give insights in the availability of cell lines and the possibilities that these cell lines might give to researchers focused on CCC.

Introduction

Cholangiocellular Carcinoma (CCC) is a malignancy arising from epithelial cells of the biliary tree. The first case of common bile duct cancer was described by Durand-Fardel in 1840 [1]. Depending on tumor location CCC are differentiated as intrahepatic or extra hepatic. The latter can be further classified as distal and perihilar. 60-70% of CCC a rise at the hepatic bifurcation (perihilar) and were first reported by Klatskin in 1965[2]. Approximately 20-30% accounts for tumors in the distal common bile duct and 5-10% for the intrahepatic type [3]. Known risk factors for cholangiocarcinoma include primary sclerosing cholangitis [4], fibrocystic liver diseases (e.g. Caroli's syndrome) [5], parasitic infection (e.g. Opisthorcis viverrini) [6], viral hepatitis and cirrhosis [7], intrahepatic biliary stones[8] and chemical carcinogen exposure (e.g. thorotrast [9], smoking and alcohol[10,11]).

The incidence rate of CCC varies widely, e.g. 1-2/100,000 in the USA and 96/100,000 in Thailand [12]. In general, in Western countries and Japan the incidence of extrahepatic CCC is higher than intrahepatic CCC, whereas in Eastern countries the opposite can be seen [13]. Epidemiologic studies indicate a global increase of incidence and mortality rate for iCCC with stable or decreasing rates for eCCC [14,15].

However, the current treatment options remain still insufficient with a 5-year overall survival rate of 5-15%. The only curative approach is surgical therapy with radical resection, but up to 80% of patients present with advanced disease initially [16].

To elaborate diagnostic and therapeutic options and improve the prognosis of patients basic science is absolutely fundamental. For this purpose, tumor cell lines are essential. Tumor cell lines are an important source of material for "omic" studies, and they allow functional studies that help to better understand tumor biology, especially molecular pathogenesis and pathophysiology [17,18].

However, the amount of cell lines derived from CCC is limited. The majority of research in CCC has been done with only two cell lines EGI-1 and TFK [19-21]. A disadvantage of a limited number of cell lines' use is that these cells cannot sufficiently represent tumor heterogeneity of CCC. Cell lines are prone to genetic drift and shift that might alter the tumor genome in the course of time. Additionally, cell lines that are cultivated long-term are prone to be contaminated with rapid growing cell lines like HeLa cells. Due to this the establishment of new cell lines is beneficial [22]. The aim of the present review gives an overview on CCC cell lines available for researchers that focus on this tumor entity. We will discuss characteristics of these cell lines as well as origin of the cell lines, techniques and medias that were used to establish these CCC cell lines.

Overview on cholangiocarcinoma cell lines

In the 19th century, the concept of tissue culture was introduced by Wilhelm Roux. Since the first successful isolation of cell lines in the 60ties, several CCC cell lines were described in literature (Table 1).

Yamaguchi established the first CCC cell line from a specimen of a intrahepatic CCC from a patient's autopsy in 1984 [23]. The specimen was minced in small pieces about 1mm diameter and then dispersed in a culture flask with Ham's F12 medium containing 0.1% FBS (fetal bovine serum). The cell line was later known as *HChol-Y1*.

The most frequent used cell line in research, *TFK-1*, was established of fragmented eCCC tumor specimen of a 63 years old male. After digesting with dispase (1,000 U/ml), it was cultured in 12-well plates using RPMI-1640 medium containing 10% FBS with antibiotic agents. The TFK-1 cells grew in polygonal epithelial monolayers with a cell doubling time of 37 hours. A modal chromosome number of 73 with some structural abnormalities was observed. The tumor markers, CEA and CA-19-9, were not found in successful xenotransplantated SCID mice. Several surface antigens were detected and revealed promising approaches for targeted therapy with e.g. cetuximab. The majority of experimental studies on CCC today is performed with this cell line.

Classification of CCC cell lines

Classification of CCC cell lines can be based on the localization of the native tumor. As already described above, cell lines can be derived from iCCC, eCCC or Klatskin CCC. A sub-classification of the cell lines from primary tumor and metastases can be made. iCCC and eCCC represent 39% and 37%, respectively of the main isolated locations of cell lines in literature. Cell lines of Klatskin tumors account only for 5% of all cell lines and 19% of CCC cell lines are derived from metastases.

Citation: Zach S, Birgin E and Rückert F. Primary Cholangiocellular Carcinoma Cell Lines. J Stem Cell Res Transplant. 2015;2(1): 1013.

Table 1: CCC cell lines described in literature.

Yamaguchi, 1985 [23]	HChol-Y1	Explant, iCCC	Ham F12 + 0.1%FBS	M, DD, HC, Chr, Xeno, TM
Knuth, 1985 [24] Andresen, 2012[1]	Mz-ChA-1	Explant, abdominal wall mets of GB	CMRL + 15%FBS + AA	M, DD, HC, Chr, Xeno, TM, FA
	Mz-ChA-2	Explant, liver mets of GB	CMRL + 15%FBS + AA	M, DD, HC, Chr, Xeno, TM, FA
	Sk-ChA-1	Ascites, eCCC-mets	CMRL + 15%FBS + AA	M, DD, HC, Chr, Xeno, TM, FA
Murakami, 1987 [28] Andresen, 2012[1]	KMCH-1	Explant, CCC/HCC	DMEM + 20%FBS + AA	M, DD, HC, Chr, Xeno, TM, FA
Scherdin, 1987 [48] Andresen, 2012[1]	EGI-1	Explant, eCCC	DMEM + 10%FBS	M, DD, IHC, mut, DNA, Xeno, FA
Homma, 1987 [49]	Oz	Ascites, iCCC-mets	W/E + 10%FBS + AA	M, DD, HC, Chr, Xeno
Kusaka, 1988 [50]	HuH-28	Explant, iCCC	RPMI 1640 + 20%FBS	M, DD, HC, Chr, Xeno, TM
Katoh, 1988 [27]	CHGS	CCC	-	M, DD, HC, Xeno
Miyagiwa, 1989 [30] Andresen, 2012[1]	HuCC-T1	Ascites, iCCC-mets	RPMI 1640 + 10%FBS + AA	M, DD, HC, IHC, Chr, mut, FA, TM, Xeno
Storto, 1990 [29] Yokomuro 2000 [51]	PCI:SG231	Explant, iCCC	DMEM + 15%FBS + AA	M, IHC; Chr, Xeno, FA
Yoshida, 1990 [52]	MEC	Pleural Effusion, eCCC-mets	-	M, DD, HC, IHC, Chr, Xeno, TM
Sirisinha, 1991 [45]	HuCCA-1	Explant, iCCC	Ham F12 + 10%FBS + AA	M, DD, HC, IHC, Chr, TM
Iemura, 1992 [31]	KMC-1	Xenograft, iCCC	DMEM + 20%FBS	M, DD, HC, Chr, TM
Shimizu, 1992 [42]	CC-SW-1	Explant, iCCC	DMEM + 15%FBS + AA	M, DD, HC, IHC, Chr, Xeno, TM, FA
	CC-LP-1	Explant, iCCC	DMEM + 15%FBS + AA	M, DD, HC, IHC, Chr, Xeno, TM, FA
Yano, 1992 [53] Andresen, 2012[1]	KMBC	Explant, eCCC	RPMI 1640 + 5%FBS + AA	M, DD, IHC, Chr, Xeno, TM, FA
Purdum, 1993 [39] Oertel, 2003 [54]	BDC	Explant, eCCC	DMEM + 10%FBS + AA	M, DD, HC, FA
Saijyo, 1995 [55] Andresen, 2012[1]	TFK-1	Explant, eCCC	RPMI 1640 + 10%FBS + AA	M, DD, IHC, Chr, Xeno, TM, FA
Yamada, 1995 [35]	OCUCh-LM1	Explant, eCCC-mets (liver)	DMEM + 10%FBS + AA	M, DD, IHC, Chr, DNA, Xeno, TM
Yano, 1996 [33]	KMCH-2	Explant, iCCC	DMEM + 20%FBS + AA	M, DD, Chr, Xeno, TM
Enjoji 1997 [41,56]	ETK1	Ascites, iCCC-mets	RPMI 1640 + 10%FBS	M, DD, HC, IHC, Chr, Xeno, FA
	RBA	Explant, iCCC	RPMI 1640 + 10%FBS	M, DD, HC, IHC, Chr, Xeno, FA
	SSP-25	Explant, iCCC	RPMI 1640 + 10%FBS	M, DD, HC, IHC, Chr, Xeno, FA

Wang, 1997 [57] Wu, 2003 [58]	QBC939	-,eCCC	DMEM + 10%FBS + AA	FA
Takiyama, 1998 [59]	ICBD-1	Explant, eCCC	DMEM + 10%FBS	M, DD, Chr, Xeno, TM, FA
Watanabe, 2000 [43]	TK	Ascites, eCCC-mets	RPMI 1640 + 15%FBS	M, DD, HC, IHC, Xeno, TM
Jiao, 2000 [34]	HBDC	Ascites, Klatskin-mets	W/E + 10%FBS	M, DD, HC, IHC, Chr, DNA, Xeno, TM, FA
Kim, 2001 [60]	SCK	Explant, eCCC	DMEM + 10%FBS + AA	M, HC, IHC, Chr, DNA
	JCK	Explant, eCCC	DMEM + 10%FBS + AA	M, HC, IHC, Chr, DNA
	Cho-CK	Explant, eCCC	DMEM + 10%FBS + AA	M, HC, IHC, Chr, DNA
	Choi-CK	Explant, eCCC	DMEM + 10%FBS + AA	M, HC, IHC, Chr, DNA
Steffen, 2001 [61] Moore 1971 [29]	RPMI 7451	Explant, -	DMEM + 15%FBS + AA	M, IHC; Chr, Xeno, FA
Ku, 2002 [18]	SNU-245	Explant, eCCC	RPMI 1640 + 10%FBS	M, DD, mut, DNA
	SNU-308	Explant, gall bladder	RPMI 1640 + 10%FBS	M, DD, mut, DNA
	SNU-478	Explant, ampulla of Vater	RPMI 1640 + 10%FBS	M, DD, mut, DNA
	SNU-869	Explant, ampulla of Vater	RPMI 1640 + 10%FBS	M, DD, mut, DNA
	SNU-1079	Explant, iCCC	RPMI 1640 + 10%FBS	M, DD, mut, DNA
	SNU-1196	Explant, Klatskin	RPMI 1640 + 10%FBS	M, DD, mut, DNA
Emura, 2003 [62]	TGBC-47	Explant, eCCC	-	M, DD, HC, IHC, Chr, TM
Ghosh, 2005 [26]	TGBC-51	Explant, ampulla of Vater	-	M, DD, HC, IHC, Chr, TM
	TBCN6	Explant, eCCC	-	M, DD, HC, IHC, Chr, TM
Sripa, 2005 [40]	KKU-100	Explant, Klatskin	Ham F12 + 20%FBS + AA	M, DD, HC, IHC, Chr, Xeno, TM
Rattanasinganchan, 2006 [44]	RMCCA-1	Explant, eCCC	Ham F12 + 20%FBS + AA	M, DD, HC, IHC, Chr, TM, FA
Ma, 2007 [63]	HKGZ-CC	Explant, iCCC	DMEM + 10%FBS + AA	M, DD, HC; Chr, Xeno
Ojima, 2010 [32]	NCC-BD1	Xenograft/Explant, eCCC	RPMI 1640 + 10%FC + AA	M, HC, IHC, mut, FA
	NCC-BD2	Xenograft/Explant, eCCC	RPMI 1640 + 10%FC + AA	M, HC, IHC, mut, FA
	NCC-CC1	Xenograft/Explant, iCCC	RPMI 1640 + 10%FC + AA	M, HC, IHC, mut, FA
	NCC-CC3-1	Xenograft/Explant, iCCC	RPMI 1640 + 10%FC + AA	M, HC, IHC, mut, FA
	NCC-CC3-2	Xenograft/Explant, iCCC	RPMI 1640 + 10%FC + AA	M, HC, IHC, mut, FA
	NCC-CC4-1	Xenograft/Explant, iCCC	RPMI 1640 + 10%FC + AA	M, HC, IHC, mut, FA
Liu, 2013 [64]	HCCC-9810	Explant, iCCC	DMEM + 10%FBS	M, DD, HC, Xeno, FA

Origin of cell lines is indicated (intrahepatic= iCCC; extra hepatic= eCCC; perihilar= Klatskin; metastasis= suffix "-Mets) (FBS= fetal bovine serum; AA= antibiotic agent; M= morphology; DD= doubling time; HC= histochemistry; IHC= immunohisto chemistry; CHR= chromosomal analysis; TM= tumor/biochemical markers; Xeno= xenograft; mut= mutational analysis; DNA= DNA index; FA= functional analysis; DMEM= Dulbecco's modified Eagle medium; W/E= Williams E medium)

Table 2: Characterization of selected CCC cell lines.

Author, Year	Cell line	Morphology	HC	DD	Chr	DNA index	mut	TM	FA
Purdum, 1993 [39] Oertel, 2003 [54]	BDC	-	-	-	-	-	-	-	Photodynamic therapy
Shimizu, 1992 [42]	CC-SW-1	LM, EM	HE	72h	-	-	-	HLA1, No AFP/ CEA/CA19-9,	Growth by insulin, inhibition by IL1-beta
	CC-LP-1	LM, EM	HE	180h	-	-	-	HLA1, No AFP/ CEA/CA19-9,	Growth by Insulin and EGF, inhibition by IL1-beta
Scherdin, 1987 [48] Andresen, 2012[1] Xu [38], 2010	EGI-1	-	-	-	-	-	kras	EGFR, HGFR, IGF1R IGF2R, VEGFR1, VEGFR2	Cetuximab; Genes for promoter methylation
Jiao, 2000 [34]	HBDC	LM,PC	HE, PAS, CEA-125, CK-19, vimentin	32.3h – 35.8h	76-93	0.85	-	CA19-9,Span-1,KMO-1, ALP, γGT	-
Yamaguchi, 1985 [23]	HChol-Y1	LM, EM	HE, PAS, anti-CEA, anti-AFP, anti CA 19-9	52h	54-70	-	-	CA 19-9, CEA, No AFP	-
Ma, 2007 [63]	HKGZ-CC	LM, PC	HE	48h	64-74	-	-	-	-
Sirisinha, 1991 [45]	HuCCA-1	LM	HE	55h	-	-	-	CA125, MCA, AFP	-
Miyagiwa, 1989 [30] Andresen, 2012[1]	HuCC-T1	-	-	-	-	-	-	-	Genes for promoter methylation
Kusaka, 1988 [50]	HuH-28	LM,PC	PAS	80h	59 (modal)	-	-	BMG, Elastase, Ferritin,TPA, ALP, γGT, No AFP/CEA/ CA19-9	-
Yano, 1992 [53] Andresen, 2012[1]	KMBC	-	-	-	-	-	-	-	Genes for promoter methylation
Knuth, 1985 [24] Andresen, 2012[1]	Sk-ChA-1	EM, PC	-	48h	61-164	-	-	CEA, NANA, PHI, LDH, HLA-I, C3/C5, α1-anti-Trypsin, α2-macro-globulin	Genes for promoter methylation
Iemura, 1992 [31]	KMC-1	LM, EM, PC	HE, PAS, mucine	54h	73-83	1.76	-	TPA,hCG, CA19-9, CEA, Ferritin	-
Murakami, 1987 [28] Andresen, 2012[1]	KMCH-1	LM, PC, EM	HE, PAS, mucicarmine	39h	60-98	-	-	No AFP, No CEA	Genes for promoter methylation
Yano, 1996 [33]	KMCH-2	LM,EM	HE, alcian blue, mucicarmine	30h	40-41	-	-	CA 19-9, TPA, CEA, Ferritin	-
Sripa, 2005 [40]	KKU-100	LM, PC	HE	72h	56-92	-	-	Cytokeratin, CEA, CA125, EMA	-
Ojima, 2010 [32]	NCC-BD1	LM	HE	-	-	-	Kras, p53 (3/5, 60%)	MAGEH-1	Gemcitabine sensitivity

	NCC-BD2	LM	HE	-	-	-	Kras, p53 (3/5, 60%)	MAGEH-1	Gemcitabine sensitivity
	NCC-CC1	LM	HE	-	-	-	Kras, p53 (3/5, 60%)	MAGEH-1	Gemcitabine sensitivity
	NCC-CC3-1	LM	HE	-	-	-	Kras, p53 (3/5, 60%)	MAGEH-1	Gemcitabine sensitivity
	NCC-CC3-2	LM	HE	-	-	-	Kras, p53 (3/5, 60%)	MAGEH-1	Gemcitabine sensitivity
	NCC-CC4-1	LM	HE	-	-	-	Kras, p53 (3/5, 60%)	MAGEH-1	Gemcitabine sensitivity
Yamada, 1995 [35]	OCUCh-LM1	LM, EM, PC	HE	31h	63 (modal)	1.76		SLX, CA-19-9, SPan, CEA	-
Homma, 1987 [49]	Oz	-	-	-	-	-	No kras mut	EGFR, HGFR, IGF1R IGF2R, VEGFR, VEGFR2	Cetuximab; genes for promoter methylation
Storto, 1990 [29] Yokomuro 2000(51)	PCI:SG231	LM, EM,PC	Anti-keratin, anti-CEA	-	67 (modal)	-	-	Keratin, CEA	-
Rattanasinganchan, 2006 [44]	RMCCA-1	LM, PC	HE	48h	54-61	-	-	CA-19-9, AE1/ AE3, MMP	Motility invasion assay
Saijyo, 1995 [55] Andresen, 2012[1] Xu [38], 2010	TFK-1	LM, EM	HE	37h	73	-	No kras mut	EGFR, HGFR, IGF1R IGF2R, VEGFR1, VEGFR2	Cetuximab;genes for promoter methylation
Watanabe, 2000 [43]	TK	LM, EM, PC	HE,PAS,anti-CEA, anti-CA-19-9	29h	66-132	-	-	CEA, CA-19-9, No AFP	-

(LM= light microscope;EM= electron microscope; PC= phase contrast microscope; HE= Hematoxylin and Eosin; PAS= Periodic Acid Shift)

In current literature, there are some cell lines derived from the biliary tract that are not particulary from CCC. These are cell lines from gall bladder cancer [24,25] cancer of the ampulla of Vater [26] and not further characterized cholangiocarcinoma cell lines [27], or from combined hepatocellular and cholangiocarcinoma neoplasms (HCC/CCC) [28].

The following table gives an overview about the 52 CCC cell lines described in literature so far (Table 1).

Isolation techniques used for the establishment of CCC cell lines

As shown in Table 1 different techniques are available to establish CCC cell lines. In general, explant culture is the most frequently used technique [29]. Processing malignant body fluids such as pleural effusion or ascites with a culture medium is another frequent method to establish cell cultures [30]. Xenografting technique is the inoculation of tumor specimens into athymic mice and provides a successful source to establish cancer lines [31,32]. Actually one must consider a fast processing time of samples which is essential for the success rate of cell lines. Contaminating cells such as fibroblasts can be mechanically removed by a sterile cannula under a phase contrast microscope or by enzymatic digestion. Typically, a varying amount (0.1% - 20%) of FBS or FC (10%) combined with antibiotic agents to reduce bacterial contamination are used for the propagation process. In literature, Ham's F12, CMRL, DMEM, Williams E and RPMI 1640 are the basic culture mediums used to establish CCC cell lines.

Characterization of CCC cell lines

The analysis of the genome, transcriptome and proteome can give interesting insights into the pathophysiology of CCC (table 2). In former times, chromosome analysis was performed by characterization and counting chromosomes in Giemsa staining with a wide range of different chromosome numbers between 40 and 164 [33]. Some authors also describe nuclei DNA content by flow cytometric methods [34,35]. Today, spectral karyotyping (SKY), a technique based on fluorescene in situ hybridization (FISH) [36], enables the painting of each chromosomes in different colors. By this means, chromosomes with unknown origin or structural abnormalities (e.g. complex translocations) can easily be identified by visual interpretation [37]. However, there was no study so far performing this analysis in CCC cell lines.

Mutational analysis is also commonly performed. Kras and p53 mutations constitute the typical genetic fingerprint of intrahepatic cholangiocellular carcinoma and this was studied in some cell lines [25,32].

Investigations of proteins involve the study of proteomes and secretomes. Depending on cell line different structural proteins e.g. receptors (EGFR, HGFR, IGF1R IGF2R, VEGFR1, VEGFR2) [38], intermediate filaments (keratin [39,40], vimentin [41]), antigens (HLA-1 [42], MAGEH-1 [32]) or secreted proteins e.g. typical tumor markers (CEA [23,24,26], CA-19-9 [43,44], AFP [44,45], CA-125 [45]) were detected. There is a heterogeneous variety of protein expression among the cell lines demonstrating the differences in tumor biology [25,32,42].

Conclusion

Basic research in cancer is absolutely dependent on cancer cell lines

to understand tumor biology. In the last three decades, several CCC cell lines could be established by researchers around the world. The establishment of primary CCC cell lines can be done with reasonable expenses and renders interesting insights into the molecular biology of CCC. The success rate of establishing cell lines is very low. The typical ratio that is given in most publications is about 10%. There are several obstacles for the successful isolation. First of all, not every (little) piece of tissue taken from a tumor sample contains tumor cells. The time from sampling to processing plays a major role and should not be too long because cells in a non-physiological environment are prone to necrosis. Even if these two obstacles are considered not every tumor sample will show growth of tumor cells, even in optimal culture conditions. An underlying reason for this might be the genetic make-up of the tumor cells [46]. Even in the rare case of outgrow that is seen in about 20% of cases there might be fungal or bacterial contamination or the cancer cell might be overgrown by fibroblasts [47]. A success rate of 10% seems very low. The effect of genetic versus other factors of influence is hard to assess. An approach to improve isolation techniques might be to test new medias or supplements for the isolation of CCC. This could be achieved by testing established CCC cell lines.

In this review, we listed systematically all established CCC cell lines in the world literature so far. By this, we hope to give researchers interested in CCC a tool to better represent the heterotypic tumor biology of CCC.

References

1. Renshaw K. Malignant Neoplasms of the Extrahepatic Biliary Ducts. Annals of surgery 1922; 76: 205-221.
2. Klatskin G. Adenocarcinoma of the Hepatic Duct at Its Bifurcation within the Porta Hepatis. An Unusual Tumor with Distinctive Clinical and Pathological Features. Am J Med 1965; 38: 241-256.
3. Nakeeb A, Pitt HA, Sohn TA, Coleman J, Abrams RA, et al. Cholangiocarcinoma. A spectrum of intrahepatic, perihilar, and distal tumors. Ann surg 1996; 224: 463-473.
4. Shaib Y, El-Serag HB. The epidemiology of cholangiocarcinoma. Seminars in liver disease 2004; 24: 115-125.
5. DMS. Gallbladder and biliary tree: anatomy and structural anomalies. In: T Y, editor. Textbook of gastroenterology. Philadelphia: Lippincott Willimas and Wilkins 1999; 2244-2257.
6. Watanapa P, Watanapa WB. Liver fluke-associated cholangiocarcinoma. Br J Surg 2002; 89: 962-970.
7. Sorensen HT, Friis S, Olsen JH, Thulstrup AM, Mellemkjaer L, et al. Risk of liver and other types of cancer in patients with cirrhosis: a nationwide cohort study in Denmark. Hepatology 1998; 28: 921-925.
8. Kubo S, Kinoshita H, Hirohashi K, Hamba H. Hepatolithiasis associated with cholangiocarcinoma. World j surg 1995; 19: 637-641.
9. Sahani D, Prasad SR, Tannabe KK, Hahn PF, Mueller PR, et al. Thorotrast-induced cholangiocarcinoma: case report. Abdominal imaging 2003; 28: 72-74.
10. Bergquist A, Glaumann H, Persson B, Broome U. Risk factors and clinical presentation of hepatobiliary carcinoma in patients with primary sclerosing cholangitis: a case-control study. Hepatology 1998; 27: 311-316.
11. Chalasani N, Baluyut A, Ismail A, Zaman A, Sood G, et al. Cholangiocarcinoma in patients with primary sclerosing cholangitis: a multicenter case-control study. Hepatology 2000; 31: 7-11.
12. Shaib Y, El-Serag HB. The prevalence and risk factors of functional dyspepsia in a multiethnic population in the United States. Am J Gastroenterol 2004; 99: 2210-2216.
13. Bragazzi MC , Carpino G, Venere R, Semeraro R, Gentile R, et al. Cholangiocarcinoma: Epidemiology and risk factors. Transl Gastrointest Cancer 2012 2012; 1: 21-32.
14. Shin HR, Oh JK, Masuyer E, Curado MP, Bouvard V, et al. Comparison of incidence of intrahepatic and extrahepatic cholangiocarcinoma--focus on East and South-Eastern Asia. Asian Pac J Cancer Prev 2010; 11: 1159-1166.
15. Patel T. Worldwide trends in mortality from biliary tract malignancies. BMC cancer 2002; 2: 10.
16. Skipworth JR, Keane MG, Pereira SP. Update on the management of cholangiocarcinoma. Digestive diseases 2014; 32: 570-578.
17. Ku JL, Yoon KA, Kim WH, Jang Y, Suh KS, et al. Establishment and characterization of four human pancreatic carcinoma cell lines. Genetic alterations in the TGFBR2 gene but not in the MADH4 gene. Cell Tissue Res 2002; 308: 205-214.
18. Ku JL, Yoon KA, Kim IJ, Kim WH, Jang JY, et al. Establishment and characterisation of six human biliary tract cancer cell lines. Br J Cancer 2002; 87: 187-193.
19. Okaro AC, Fennell DA, Corbo M, Davidson BR, Cotter FE. Pk11195, a mitochondrial benzodiazepine receptor antagonist, reduces apoptosis threshold in Bcl-X(L) and Mcl-1 expressing human cholangiocarcinoma cells. Gut 2002; 51: 556-561.
20. Huether A, Hopfner M, Baradari V, Schuppan D, Scherubl H. Sorafenib alone or as combination therapy for growth control of cholangiocarcinoma. Biochemical pharmacology 2007; 73: 1308-1317.
21. Fabris L, Cadamuro M, Moserle L, Dziura J, Cong X, et al. Nuclear expression of S100A4 calcium-binding protein increases cholangiocarcinoma invasiveness and metastasization. Hepatology 2011; 54: 890-899.
22. Masters JR, Thomson JA, Daly-Burns B, Reid YA, Dirks WG, et al. Short tandem repeat profiling provides an international reference standard for human cell lines. Proc Natl Acad Sci U S A 2001; 98: 8012-8017.
23. Yamaguchi N, Morioka H, Ohkura H, Hirohashi S, Kawai K. Establishment and characterization of the human cholangiocarcinoma cell line HChol-Y1 in a serum-free, chemically defined medium. J Natl Cancer Inst 1985; 75: 29-35.
24. Knuth A, Gabbert H, Dippold W, Klein O, Sachsse W, et al. Biliary adenocarcinoma. Characterisation of three new human tumor cell lines. J hepatol 1985; 1: 579-596.
25. Andresen K, Boberg KM, Vedeld HM, Honne H, Hektoen M, et al. Novel target genes and a valid biomarker panel identified for cholangiocarcinoma. Epigenetics 2012; 7: 1249-1257.
26. Ghosh M, Koike N, Tsunoda S, Hirano T, Kaul S, et al. Characterization and genetic analysis in the newly established human bile duct cancer cell lines. Int J Oncol 2005; 26: 449-456.
27. Katoh H, Shinbo T, Otagiri H, Saitoh M, Saitoh T, et al. [Character of a human cholangiocarcinoma CHGS, serially transplanted to nude mice]. Human cell 1988; 1: 101-105.
28. Murakami T, Yano H, Maruiwa M, Sugihara S, Kojiro M. Establishment and characterization of a human combined hepatocholangiocarcinoma cell line and its heterologous transplantation in nude mice. Hepatology 1987; 7: 551-556.
29. Storto PD, Saidman SL, Demetris AJ, Letessier E, Whiteside TL, et al. Chromosomal breakpoints in cholangiocarcinoma cell lines. Genes Chromosomes Cancer 1990; 2: 300-310.
30. Miyagiwa M, Ichida T, Tokiwa T, Sato J, Sasaki H. A new human cholangiocellular carcinoma cell line (HuCC-T1) producing carbohydrate antigen 19/9 in serum-free medium. In Vitro Cell Dev Biol 1989; 25: 503-510.
31. Iemura A, Maruiwa M, Yano H, Kojiro M. A new human cholangiocellular carcinoma cell line (KMC-1). Journal of hepatology 1992; 15: 288-298.
32. Ojima H, Yoshikawa D, Ino Y, Shimizu H, Miyamoto M, et al. Establishment of six new human biliary tract carcinoma cell lines and identification of MAGEH1 as a candidate biomarker for predicting the efficacy of gemcitabine treatment. Cancer sci 2010; 101: 882-888.

33. Yano H, Iemura A, Haramaki M, Momosaki S, Ogasawara S, et al. A human combined hepatocellular and cholangiocarcinoma cell line (KMCH-2) that shows the features of hepatocellular carcinoma or cholangiocarcinoma under different growth conditions. J hepatol 1996; 24: 413-422.

34. Jiao W, Yakushiji H, Kitajima Y, Ogawa A, Miyazaki K. Establishment and characterization of human hilar bile duct carcinoma cell line and cell strain. J Hepatobiliary Pancreat Surg 2000; 7: 417-425.

35. Yamada N, Chung YS, Arimoto Y, Sawada T, Seki S, et al. Establishment of a new human extrahepatic bile duct carcinoma cell line (OCUCh-LM1) and experimental liver metastatic model. Br j cancer 1995; 71: 543-548.

36. Schrock E, du Manoir S, Veldman T, Schoell B, Wienberg J, et al. Multicolor spectral karyotyping of human chromosomes. Science 1996; 273: 494-497.

37. Imataka G, Arisaka O. Chromosome analysis using spectral karyotyping (SKY). Cell biochemistry and biophysics 2012; 62: 13-17.

38. Xu L, Hausmann M, Dietmaier W, Kellermeier S, Pesch T, et al. Expression of growth factor receptors and targeting of EGFR in cholangiocarcinoma cell lines. BMC cancer 2010; 10: 302.

39. Purdum PP 3rd, Ulissi A, Hylemon PB, Shiffman ML, Moore EW. Cultured human gallbladder epithelia. Methods and partial characterization of a carcinoma-derived model. Lab Invest 1993; 68: 345-353.

40. Sripa B, Leungwattanawanit S, Nitta T, Wongkham C, Bhudhisawasdi V, et al. Establishment and characterization of an opisthorchiasis-associated cholangiocarcinoma cell line (KKU-100). World J Gastroenterol 2005; 11: 3392-3397.

41. Enjoji M, Nakashima M, Honda M, Sakai H, Nawata H. Hepatocytic phenotypes induced in sarcomatous cholangiocarcinoma cells treated with 5-azacytidine. Hepatology 1997; 26: 288-294.

42. Shimizu Y, Demetris AJ, Gollin SM, Storto PD, Bedford HM, et al. Two new human cholangiocarcinoma cell lines and their cytogenetics and responses to growth factors, hormones, cytokines or immunologic effector cells. International journal of cancer 1992; 52: 252-260.

43. Watanabe M, Chigusa M, Takahashi H, Nakamura J, Tanaka H, et al. High level of CA19-9, CA50, and CEA-producible human cholangiocarcinoma cell line changes in the secretion ratios in vitro or in vivo. In vitro cellular and developmental biology Animal 2000; 36: 104-109.

44. Rattanasinganchan P, Leelawat K, Treepongkaruna SA, Tocharoentanaphol C, Subwongcharoen S, et al. Establishment and characterization of a cholangiocarcinoma cell line (RMCCA-1) from a Thai patient. World J Gastroenterol 2006; 12: 6500-6506.

45. Sirisinha S, Tengchaisri T, Boonpucknavig S, Prempracha N, Ratanarapee S, et al. Establishment and characterization of a cholangiocarcinoma cell line from a Thai patient with intrahepatic bile duct cancer. Asian Pac J Allergy Immunol 1991; 9: 153-157.

46. Rückert F, Pilarsky C, Grützmann R. Establishment of Primary Cell Lines in Pancreatic Cancer. Pancreatic Cancer - Molecular Mechanism and Targets 2012; 259-275.

47. Ruckert F, Aust D, Bohme I, Werner K, Brandt A, et al. Five primary human pancreatic adenocarcinoma cell lines established by the outgrowth method. J Surg Res 2012; 172: 29-39.

48. Scherdin U GM, Klouche M. In vitro interaction of a difluoromethyl-ornithine (DFMO) and human recombinant interferon-alpha (rIFN-alpha) on human cancer cell lines. Immunobiology 1987; 175: 1-143.

49. Homma S, Nagamori S, Fujise K, Yamazaki K, Hasumura S, et al. Human bile duct carcinoma cell line producing abundant mucin in vitro. Gastroenterol Jpn 1987; 22: 474-479.

50. Kusaka Y, Tokiwa T, Sato J. Establishment and characterization of a cell line from a human cholangiocellular carcinoma. Res Exp Med (Berl) 1988; 188: 367-375.

51. Yokomuro S, Tsuji H, Lunz JG 3rd, Sakamoto T, Ezure T, et al. Growth control of human biliary epithelial cells by interleukin 6, hepatocyte growth factor, transforming growth factor beta1, and activin A: comparison of a cholangiocarcinoma cell line with primary cultures of non-neoplastic biliary epithelial cells. Hepatology 2000; 32: 26-35.

52. Yoshida K, Tomizawa H, Ota T, Nagashima T, Kikuchi H, et al. [Establishment and characterization of human cholaginocarcinoma, MEC, producing carbohydrate antigen 19-9]. Human cell 1990; 3: 346-351.

53. Yano H, Maruiwa M, Iemura A, Mizoguchi A, Kojiro M. Establishment and characterization of a new human extrahepatic bile duct carcinoma cell line (KMBC). Cancer 1992; 69: 1664-1673.

54. Oertel M, Schastak SI, Tannapfel A, Hermann R, Sack U, et al. Novel bacteriochlorine for high tissue-penetration: photodynamic properties in human biliary tract cancer cells in vitro and in a mouse tumour model. J Photochem Photobiol B 2003; 71: 1-10.

55. Saijyo S, Kudo T, Suzuki M, Katayose Y, Shinoda M, et al. Establishment of a new extrahepatic bile duct carcinoma cell line, TFK-1. Tohoku J Exp Med 1995; 177: 61-71.

56. Enjoji M, Sakai H, Nawata H, Kajiyama K, Tsuneyoshi M. Sarcomatous and adenocarcinoma cell lines from the same nodule of cholangiocarcinoma. In Vitro Cell Dev Biol Anim 1997; 33: 681-683.

57. Wang SG HB, Duan HC, Chen YS, Peng ZM. Establishment of the extrahepatic cholangiocarcinoma cell line. Zhonghua Shiyan Waike Zazhi (Chinese Journal of Experimental Surgery) 1997; 14: 67-68.

58. Wu GS, Zou SQ, Luo XW, Wu JH, Liu ZR. Proliferative activity of bile from congenital choledochal cyst patients. World J Gastroenterol 2003; 9: 184-187.

59. Takiyama I, Terashima M, Ikeda K, Kawamura H, Kashiwaba M, et al. Establishment and characterization of a new human extrahepatic bile duct carcinoma cell line (ICBD-1). Oncol Rep 1998; 5: 463-467.

60. Kim DG, Park SY, You KR, Lee GB, Kim H, et al. Establishment and characterization of chromosomal aberrations in human cholangiocarcinoma cell lines by cross-species color banding. Genes Chromosomes Cancer 2001; 30: 48-56.

61. Steffen M, Zuehlke I, Scherdin U. Motility factors identified in supernatants of human cholangiocarcinoma cell lines. Int J Oncol 2001; 18:1107-1112.

62. Emura F, Kamma H, Ghosh M, Koike N, Kawamoto T, et al. Establishment and characterization of novel xenograft models of human biliary tract carcinomas. Int J Oncol 2003; 23: 1293-1300.

63. Ma S, Hu L, Huang XH, Cao LQ, Chan KW, et al. Establishment and characterization of a human cholangiocarcinoma cell line. Oncol rep 2007; 18: 1195-2000.

64. Liu J, Han G, Liu H, Qin C. Suppression of cholangiocarcinoma cell growth by human umbilical cord mesenchymal stem cells: a possible role of Wnt and Akt signaling. PloS one 2013; 8: e62844.

J Stem Cell Res Transplant - Volume 2 Issue 1 - 2015
ISSN : 2381-9065 | www.austinpublishinggroup.com

Citation: Zach S, Birgin E and Rückert F. Primary Cholangiocellular Carcinoma Cell Lines. J Stem Cell Res Transplant. 2015;2(1): 1013.